AECOM

Baboosic Lake (Pine Knoll Shores) Drainage Study

Final Engineering Report & Conceptual Design

Town of Merrimack Department of Public Works

Project number: 60680349

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Prepared for:

Town of Merrimack
Department of Public Works
6 Baboosic Lake Road
Merrimack, NH 03054

New Hampshire Department of Environmental Services
Watershed Management Bureau
29 Hazen Drive, P.O. Box 95
Concord, NH 03302

Prepared by:

AECOM
250 Apollo Drive
Chelmsford, MA 01824
aecom.com

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Abbreviations

ac.	Acre
AoT	Alteration of Terrain
BLA	Baboosic Lake Association
BMP	Stormwater Best Management Practice
C-CAP	Coastal Change Analysis Program
CAD	Computer-Aided Drafting and Design
CEI	Comprehensive Environmental, Incorporated
cfs	cubic feet per second
chl-a	*chlorophyll-a*
CMP	Corrugated Metal Pipe
Contech	Contech Engineered Systems, inc.
CWA	Clean Water Act
CWSRF	Clean Water State Rotating Fund
CY	Cubic Yard
DPW	Department of Public Works

EMC	Event Mean Concentration
ENSR-LRM	ENSR Lake Loading Response Model
GRANIT	New Hampshire GIS Clearinghouse
Hancock	Hancock Survey Associates, Inc.
HDPE	High Density Polyethylene
HSG	Hydrologic Soil Group
in	inches
IUP	Intended Use Plan
K	Thousand
lb/yr	pounds per year
lb/ac/yr	pounds per acre per year
LiDAR	Light Detection and Ranging
M	Million
mg/L	milligrams per liter
min/in	minutes per inch
NAVD88	North American Vertical Datum of 1988
NGVD29	National Geodetic Vertical Datum of 1929
NH	New Hampshire
NH MS4	New Hampshire Municipal Separate Storm Sewer
NHCRHC	New Hampshire Coastal Risks and Hazards Commission
NHDES	New Hampshire Department of Environmental Services
NOAA	National Oceanographic and Atmospheric Administration
NOI	Notice of Intent
NRCC	Northeast Regional Climate Center
NRPC	Nashua Regional Planning Commission
O&M	Operations and Maintenance
PCI	Pavement Condition Inventory
PDF	Portable Document Format
PPL	Project Priority List
RCP	Reinforced Concrete Pipe
ROW	Right-of-Way
Subdivision	Pine Knoll Shores Subdivision
SHWT	Seasonal High Water Table
TBF	Tree Box Filter
TMDL	Total Maximum Daily Load
Town	Town of Merrimack
TN	Total Nitrogen
TP	Total Phosphorous
TSS	Total Suspended Solids
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
WBP	Watershed-Based Plan
WSS	Web Soil Survey
WQV	Water Quality Volume

Executive Summary

The Baboosic Lake (Pine Knoll Shores) Drainage Study was funded through the New Hampshire Department of Environmental Services (NHDES) Clean Water State Revolving Fund (CWSRF) loan program. The study was performed by AECOM in close collaboration with the Town of Merrimack Department of Public Works (DPW) and NHDES.

The 57-acre Pine Knoll Shores Subdivision is located along the northwestern edge of the Town of Merrimack and along the eastern shore of Baboosic Lake. The subdivision includes approximately 142 parcels served mostly by unpaved roads with limited drainage infrastructure. The subdivision is part of the greater Baboosic Lake watershed, which was assessed for total phosphorous impairment (2011) and is listed on the Federal Clean Water Act (CWA) Section 303 (d) list of impaired waters. The objective of this study was to propose stormwater conveyance and treatment improvements for the Subdivision that, when implemented, will result in tangible water quality benefits to Baboosic Lake. The project approach included three key elements:

1) **Existing Conditions Assessment**: A detailed review of Subdivision's current roadway and drainage infrastructure, land use and soil characteristics was conducted, alongside a topographic survey. A water quality washoff analysis was performed to characterize pollutant loading of total suspended solids (TSS), total phosphorus (TP), and total nitrogen (TN) in the stormwater runoff discharge from the subdivision. The assessment identified sources of pollutants within the Subdivision and provided basis to formulating design concepts.
2) **Alternatives Evaluation**: Several potential design alternatives for the subdivision were evaluated, including drainage improvement, road cover rehabilitation, and stormwater runoff treatment. The footprint of all implementations considered were limited to the Town's right-of-way or parcels owned by the Town. Each alternative was evaluated for factors including pollutant reduction, abutter impact, construction cost, long-term operation and maintenance needs, traffic management, permitting, and funding.
3) **Conceptual Design Development**: For the design alternatives selected, a concept-level design plan was developed.

In all, this study identified seven (7) projects summarized in **Section 4** for implementation within the Subdivision. Road cover improvement through roadway paving is expected to achieve the most reductions in loading of TSS, TP, and TN. Tree box filters, vegetated swales, and hydrodynamic separators provide localized water quality treatment in space-tight areas. In addition to these right-of-way implementations, three regional treatment practices were recommended in down-gradient Town-owned parcels located on Miriam Road, Mayhew Road, and Richard Road. These regional practices employ several treatment techniques including stormwater wetlands and bioretention cells (rain gardens). The Miriam Road stormwater treatment area and interactive public park will serve as a demonstration project to promote public education and outreach for stormwater management.

The study included an approximate cost estimate for the recommended projects with implementation strategy and phasing logistics based on input from DPW and NHDES.

1. Introduction

This report outlines the assessments and results of a drainage study performed for the Pine Knoll Shores Subdivision (the Subdivision) along the banks of Baboosic Lake in the Town of Merrimack, New Hampshire. The goal of this study is to propose stormwater conveyance and treatment improvements for the Subdivision that, when implemented, will result in tangible water quality benefits to Baboosic Lake. The Subdivision roads included in this project are Longa Road, Mayhew Road, Carter Road, Miriam Road, Richards Road, Shore Drive, Thomas Road, Donald Road, and Arnold Road. The study included an assessment of current conditions to establish the baseline pollutant loading rates from the subdivision, and then developed conceptual-level design alternatives to reduce this pollutant loading, including roadway and drainage improvements and stormwater best management practices (BMPs). These recommendations were developed to reduce the loading of total phosphorous and other pollutants to Baboosic Lake, which is a nutrient-impaired waterbody.

This Project was funded through the New Hampshire Department of Environmental Services (NHDES) Clean Water State Revolving Fund (CWSRF) loan program.

1.1. Site Description

The Pine Knoll Shores Subdivision is located along the northwestern edge of the Town of Merrimack, on the eastern shore of Baboosic Lake. The subdivision was created in 1930, initially developed as a series of camps along the edge of Baboosic Lake. The subdivision consists of approximately 142 parcels that are used as primary or secondary residences (Geosyntec Consultants, 2008). There are currently 3 vacant town-owned parcels located on Mariam Road, Mayhew Road, and Richards Road. A locus map for the subdivision is included in **Figure 1-1**. The Figure also shows two stormwater outfalls in the Town's NH MS4 program (New Hampshire Municipal Separate Storm Sewer System). Drinking water for the subdivision is provided by a public water utility, but the entire Subdivision relies on septic systems for waste disposal. **Figure 1-1** also shows the boundary of the Pine Knoll Shore Drainage Basin, which is part of the Baboosic Lake TMDL watershed defined in the 2011 Baboosic Lake TMDL report.

Access to the majority of parcels within the Subdivision is provided by unpaved road surfaces with limited drainage infrastructure. Carter Road, Shore Drive, and the western portion of Longa Road are the only roadways that are paved. Drainage infrastructure in the Subdivision is limited to two small stormwater drainage networks serving the western third of the subdivision and discharging to Baboosic Lake at the end of Carter Road and in the center of Shore Drive. The Carter Road outfall is included in the Town's NH MS4 permit. The Town owns several properties within the Subdivision that are included for consideration of stormwater management infrastructure placement as part of this study.

Baboosic Lake is a 230-acre waterbody spanning the border between the Towns of Amherst and Merrimack, New Hampshire (NH). The lake is located within the Merrimack River Basin and has a total watershed of approximately 1,670 acres. Baboosic Lake has a standing TMDL for total phosphorous (AECOM, 2011). In addition, the lake is home to several public and private beaches and is listed as impaired pH for the designated use of primary contact recreation on the Federal Clean Water Act (CWA) Section 303(d) list of impaired waterbodies (see **Section 1.2.1** for details). Previous Studies

1.1.1. 2008 Watershed-Based Plan

In 2008, NHDES and Geosyntec Consultants developed a Watershed-Based Plan (WBP) for Baboosic Lake following the lake's inclusion in the *Draft 2008 List of Threatened or Impaired Waters that Require a TMDL*. The WBP sought to quantify sources of total phosphorous (TP) loading to the lake using land-use based washoff modeling, and to develop a management plan to reduce TP loading to the lake (Geosyntec Consultants, 2008).

The washoff analysis used in the WBP was based on land use data provided by the National Oceanographic and Atmospheric Administration (NOAA) Coastal Change Analysis Program (C-CAP) and land-use TP export coefficients derived from the New Hampshire Geographic Information System (GIS) Clearinghouse (GRANIT). The sub-watersheds used in the WBP analysis were comparable to the watershed delineations to the Total Maximum Daily Load (TMDL) analysis for Baboosic Lake (see **Section 1.2.2**). The WBP washoff analysis determined that the 256-acre watershed containing the Pine Knoll Shores subdivision contributed approximately 64 pounds per year (lb/yr) of

TP. Further, the analysis determined that overland stormwater pollutant washoff is responsible for about 46% of the total TP loading to the lake, with septic systems and groundwater responsible for about 43% of the total loading. The remaining TP is contributed by atmospheric deposition (Geosyntec Consultants, 2008).

The WBP identified several different management options to reduce TP loading to the lake, including stormwater management, road surface improvement, septic system improvement and centralization, fertilizer use reductions, and agricultural runoff management. The stormwater management and road surface improvement options presented included soil stabilization, unpaved road management, stormwater BMP installation, and conveyance improvements. These general practices were followed by 17 site-specific implementable projects across the Baboosic Lake watershed, two of which were located within the Pine Knoll Shores subdivision:

1. Site #14: Recommended the installation of stormwater treatment and conveyance BMPs (vegetated swale and stormwater basin) along the unpaved stretch of Carter Road between Shore Drive and Baboosic Lake, as well as channel stabilization improvements downstream of the Carter Road Outfall.
2. Site #16: Recommended the installation of a prefabricated bioretention cell upstream of the Shore Drive outfall, followed by the installation of a stabilized stormwater drainage channel connecting the shore drive outfall to Baboosic Lake.

Since the publication of the WBP, both projects have been implemented to some extent. The unpaved section of Carter Road was stabilized by the abutting homeowners, and riprap-lined drainage channels were installed to provide stabilized roadside conveyance. No treatment BMPs were installed, nor was stabilization work conducted downstream of the outfall. At the Shore Drive outfall, a pocket bioretention cell was installed at the location indicated by the WBP (see **Section 1.2.3**), but no improvements were made to improve the conveyance from the outfall to the lake.

1.1.2. 2011 Total Maximum Daily Load Assessment

In January of 2011, AECOM (formerly ENSR Corporation) published a TMDL analysis in partnership with the NHDES for Baboosic Lake. Per the TMDL report, Baboosic Lake was included on the 2006 and 2008 Section 303(d) lists of the CWA "due to the impairment of primary contact recreation caused by high chlorophyll a (chl a) concentrations and the presence of hepatotoxic cyanobacteria. High levels of chl a and hepatotoxic cyanobacteria are indicative of nutrient enrichment." (AECOM, 2011) As phosphorous is the primary limiting nutrient in northern lake systems, TP was identified as the likely cause of eutrophication and the subject of the Baboosic Lake TMDL. The goals of the TMDL analysis included quantifying the existing loading and sources of TP contribution to the lake, estimation of the lake's TP loading capacity, and suggestion of elements to be included in plans for the implementation of the TMDL (AECOM, 2011).

The modeling conducted in support of the TMDL analysis utilized the ENSR Lake Loading Response Model (ENSR-LRM), a portion of which includes a land use-based washoff model to determine the TP loading contributed from watershed washoff sources. Using this method, the 238-acre watershed containing the Pine Knoll Shores Subdivision was determined contribute 38.1 lb/yr of TP. Further, the TMDL modeling determined that overland stormwater pollutant washoff is responsible for the majority (69%) of the total TP loading to the lake, with septic systems and groundwater responsible for about 14% of the total loading. The remaining TP is contributed by atmospheric deposition, internal loading, and waterfowl (AECOM, 2011).

To meet the maximum nutrient loading needed to allow primary contact recreation in Baboosic Lake, the TMDL analysis recommended a reduction of 44% be made to all watershed contributions of TP. To meet this target reduction, the TMDL report pointed to the WBP published in 2008 (**Section 1.2.1**); which proposed specific septic and stormwater improvement projects to be implemented across the Baboosic Lake watershed. As of publication of the TMDL, several of these projects had been implemented and more were under way (AECOM, 2011).

1.1.3. 2012 Pine Knoll Shores Stormwater Improvements

As part of the implementation of the 2008 WBP, Comprehensive Environmental Inc. (CEI) and the Baboosic Lake Association (BLA) designed and installed several retrofit BMPs within the Pine Knoll Shores Subdivision in the Town of Merrimack. These implementations were funded through the United States Environmental Protection Agency (USEPA) / NHDES Watershed Assistance Grant Program and were constructed in 2012. These retrofits included the following BMP retrofits (CEI, 2011):

- A vegetated channel and riprap-lined plunge pool at the southeastern corner of the intersection between Longa Road and Rennie Road, accepting roadway, culverted, and channelized runoff and discharging to a culvert crossing Rennie Road.
- A vegetated channel and riprap-lined plunge pool at the northeastern corner of the intersection between Miriam Road and Arnold Road, accepting roadway runoff and discharging to a roadside ditch.
- A bioretention cell between 20 Shore Drive and 22 Shore Drive; accepting roadway runoff and discharging to forests downgradient.
- A bioretention cell between 18 Shore Drive and 20 Shore Drive; accepting roadway and culverted runoff and immediately discharging to the Shore Drive stormwater outfall.
- A bioretention cell at the northwestern corner of Carter Road and Arnold Road, accepting roadway runoff and discharging to a culvert crossing Arnold Road.

During field visits to the Subdivision conducted by AECOM as part of this drainage study (see **Section 2.1**), the stormwater BMPs implemented by CEI and the BLA were no longer in place; with the exception of the bioretention cell at the Shore Drive outfall. Based on discussions with the Town, the party responsible for the operation and maintenance (O&M) for these implementations is unknown, and the BMPs appear to have silted in over time.

1.1.4. 2014 Watershed-Based Plan Update

In 2014, the NHDES and the Nashua Regional Planning Commission (NRPC) issued an update to the 2008 WBP to summarize activities, data, and reports that had been developed in the five years following the initial publication of the WBP. Over that time period, stormwater and septic projects were implemented by the BLA and the Towns of Merrimack and Amherst such that approximately 40 pounds of annual TP loading were claimed to be reduced. However, the lake remained impaired and an additional 20 pounds of annual TP loading needed to be reduced to meet the goals of the WBP (NRPC, 2014).

The WBP update also provided a status update of the projects recommended in the 2008 WBP, including which had been completed and which had yet to be implemented. Of the 17 projects listed in the WBP, only four remained outstanding – including the stormwater improvements at Site 14 (Carter Road) (NRPC, 2014).

To provide further TP reductions, the WBP recommended several additional steps that could be implemented by the Town of Merrimack, including the implementation of targeted street sweeping, catch basin cleaning, and the reduction of fertilizer use on municipal land (NRPC, 2014)

1.2. Project Objectives & Approach

This drainage study was conducted to develop stormwater management design concepts with the goal of reducing the loading of total phosphorus loading to Baboosic Lake from the Subdivision. By comparing to the base-line existing condition pollutant loading rates, this study will demonstrate the expected pollutant reductions that can be achieved through the implementation of a series of stormwater management and drainage improvement measures tailored to the Subdivision.

1.2.1. Project Approach

A three-step approach was taken to meet the project objectives listed above:

1. **Existing Conditions Assessment:** An evaluation was first conducted of the Subdivision's current roadway and drainage infrastructure, land use, and soil characteristics to determine the baseline stormwater runoff and pollutant loading from the Subdivision. A topographic, right-of-way (ROW), and ground features survey was conducted, and Town data on soil characteristics, roadway quality, and land use were aggregated. This assessment identified sources of pollutants within the Subdivision and a provided basis to formulating design alternatives.
2. **Alternatives Evaluations:** With the existing Subdivision conditions defined, AECOM began evaluating potential options for drainage improvement, road cover rehabilitation, and stormwater treatment practices. Development

of these design alternatives considered many factors, including ROW width, traffic management, pollutant reductions, abutter impact, long-term maintenance needs, implementation cost, and grant eligibility.

3. **Conceptual Design Development:** Through an iterative process with the Town and NHDES, specific implementations for roadway improvements and stormwater treatment were selected and grouped into four implementation phases for ease of management by the Town. Conceptual level design plans were assembled along with preliminary estimate of construction cost.

1.2.2. Project Funding and Grant Requirements

This study was funded by a CWSRF Stormwater Planning Loan as part of the NHDES Clean Water State Revolving Fund program, included in the 2020 CWSRF Intended Use Plan (IUP) and Project Priority List (PPL). To fulfill the CWSRF loan requirements, the joint project team of Town DPW, NHDES, and AECOM held a project kick-off meeting, mid-level meetings, and a wrap-up meeting to communicate progress and solicitate input. Agendas, minutes, and attendance logs from these meetings are included in this report as **Appendix A**.

2. Data Collection

Prior to beginning the existing conditions evaluation, AECOM conducted an extensive data collection effort to collect develop a baseline for the rest of the drainage study. This section provides an overview of the efforts undertaken and the data that was gathered from these efforts.

2.1. Site Visit

On April 13, 2022, AECOM engineers visited the Subdivision and walked the site alongside representatives from the Town Department of Public Works (DPW) and Hancock Survey Associates, Inc. (Hancock), the contractor selected to conduct the topographic and feature survey. The area had received rainfall in the 48 hours preceding the site visit, and overland flow paths, recent incisions, and patterns of sediment movement were evident in the roads, swales, and catchments of the Subdivision.

During the site visit, AECOM confirmed the presence of existing drainage infrastructure against the stormwater survey conducted in 2001 for the Merrimack Village District (Meridian Land Services, Inc., 2001). The impact of runoff from the unpaved road surfaces was clearly observed to wash off sediments towards the Lake. Multiple catch basins were fully silted in with sand and debris and some roadside swales had silted in up to or beyond the crown elevation of the inlet and outlet pipes. The retrofit BMPs installed in 2012 (**Section 1.2.3**) did not appear to be functional. Several were partially or completely silted in, and others were unable to be located in the field.

Three Town-owned parcels (see **Figure 1-1**) were also assessed during the site visit to evaluate ground conditions for potential siting of regional BMPs:

- 12 Mayhew Road (Lot no. 6A2-110) is forested with little underbrush and had some residual ponding or standing water left over from recent rain events. Evidence of sediment-laden runoff entering the site from Mayhew Road was apparent.
- 5 Richards Road (Lot no. 6A2-145) is generally covered by dense brush and trees. The ground conditions were dry at the time of the visit.
- 18 Miriam Road (Lot no. 6A2-58), the largest Town-owned lot in the Subdivision, is characterized by a relatively flat, upland clearing on its eastern end; a steep hillslope in the center of the parcel; and a gently sloping forested lowland area on its western end. Remnants of a wellhead or septic system were visible in the upland clearing. Standing water and evidence of sediment-laden stormwater runoff entering the site from Miriam Road were observed on the eastern lowland area.

A photolog documenting AECOM's April site visit is included in this report as **Appendix B**.

2.2. Subdivision Surveys

The subdivision surveys described in this section were used to develop the existing conditions basemap, presented in Sheets V-1 through V-7 of **Appendix C**.

2.2.1. 2001 Merrimack Village District Survey

During the initial phases of data collection for this study, the Town provided records of a topographic and utility survey conducted in 2001 by Meridian Land Services, Inc. (Meridian) for the Merrimack Village District in support of the installation of a water main and distribution system through the Subdivision. The survey included topographic contours, drainage system features and elevations, overhead electric power lines, parcel limits, and the proposed water main alignments. The survey was bounded within the limits of the Town ROW. The 2001 survey did not include Thomas Road or the eastern portions of Miriam and Mayhew roads. The vertical datum for the 2001 survey was the National Geodetic Vertical Datum of 1929 (NGVD29).

2.2.2. Project Survey

In support of this drainage study, a topographic, ROW, and drainage network survey of the Subdivision was performed by Hancock between June and July of 2022. The topographic coverage developed by the project survey was developed using the NH State Light Detection and Ranging (LiDAR) topographic dataset and was ground-truthed to field measurements. Parcels, parcel owners, and the limits of the Town ROW were referenced from available GIS datasets. The edge and type of road covers were surveyed for all Subdivision roads, including centerline profiles and bank elevations of roadside ditches (where present). Finally, the rim elevations of stormwater drainage structures in the Subdivision were field measured to calculate connecting pipe inverts based on the offsets shown in the 2001 Meridian survey where available. Stormwater structures that were not included in the 2001 survey were opened and all inverts were measured.

All elevations were recorded in the North American Vertical Datum of 1988 (NAVD88).

2.3. Other Data Sources

In addition to the site visit and survey collection, the following datasets and sources were referenced in support of this drainage study:

- United States Department of Agriculture (USDA) Web Soils Survey (WSS) coverage of the Subdivision
- Test pit and soil infiltration data from historic Town septic system permitting records (Sheets V-1 through V-7 of **Appendix C**)
- Building footprint, driveway footprint, and waterbody datasets from the Town GIS database
- New Hampshire aerial imagery from the GRANIT GIS Repository
- Interviews and field reconnaissance conducted by Town Staff on abutter impacts regarding the Shore Drive outfall
- Town DPW 2021 Pavement Condition Inventory (PCI)

3. Existing Conditions Evaluation

To provide a baseline for the drainage improvements proposed in this study, an evaluation of the Subdivision's existing hydrology, land use, and washoff characteristics was first conducted. This section provides a summary of the methodologies undertaken and the results of these assessments.

3.1. Environmental Setting

3.1.1. Roadway and Right-of-Way

As mentioned in **Section 1.1**, all roads within the Subdivision with the exception of Carter Road, Shore Drive, and a portion of Longa Road are unpaved. During the site visit conducted in April 2022, some gravel roads were noticeably eroding, contributing to silted-in catch basins and swales as well as gullies forming through other roads. In the Town's 2021 PCI, the pavement condition for the existing asphalt cover of Carter Road and the northern portion of Shore Drive was identified as "poor"; the paved portion of Longa as "fair", and the southern portion of Shore as "good".

The widths of the Town ROW along the roadways varies across the Subdivision, and are shown in **Figure 3-1**. Carter Road and Shore Drive, each have 40-foot ROWs. Miriam, Thomas, and Mayhew Rads, as well as the eastern portion of Longa Road all have 30-foot ROWs. Rennie Road has a 25-foor ROW, and all other roads have a 20-foot ROW.

3.1.2. Stormwater Drainage Network

Elevation, material, and alignment data for the Subdivision's existing stormwater network were included in the project survey conducted by Hancock. The existing stormwater collection and conveyance system is generally limited to the extent of the paved portions of Cater Road, Longa Road, and Shore Drive, augmented by a small number of roadside ditches and culverts serving the remainder of the Subdivision. The existing conveyance system consists of 12-inch (in.) to 18-in. diameter reinforced concrete pipe (RCP) and corrugated metal pipe (CMP), generally with two to three feet of cover atop the conduit. During the site visit conducted in April 2022, DPW staff indicated that the existing drainage system has been in place for several decades without major revision or modification and requires frequent maintenance to remove sediment from the structures. The existing drainage system alignment is shown on Sheets V-1 through V-7 of **Appendix C**.

As discussed in **Section 1.1**, the Subdivision has two stormwater outfalls that drain to Baboosic Lake. The first, located at the end of Carter Road, is a 12" CMP that discharges to a three-foot-wide drainage ditch flowing downslope into the Lake. This outfall is included within the in the Town's NH MS4 regulated area and is located within a dedicated drainage easement held by the Town. The second outfall is a short length of 12" CMP that discharges into a small asphalt-lined swale running alongside the driveway of 20 Shore Drive. Flow from the outfall follows the swale down the driveway and over a section of grassed lawn before discharging to the lake. This outfall is identified by the homeowner as a source of frequent nuisance flooding. The asphalt swale is located on a privately-held easement over which the Town caries no access agreement or ownership. The Shore Drive outfall is not located within the Town's NH MS4 regulated area.

3.1.3. Soils & Land Cover

The USDA WSS coverage characterizes all soils within the 57-acre subdivision as Canton Fine Sandy Loam, very stony; classified as Hydrologic Soils Group (HSG) Type B. HSGs are determined for each soil type based on estimates of runoff potential, with group B representing soils with a moderate infiltration rate when thoroughly wet; typically including deeper, well-drained soils with a moderately fine to moderately coarse texture.

The construction of stormwater BMPs, especially those that involve infiltration or require standing water, require site-specific soil investigation (through the use of infiltration testing or test pitting) following the procedures listed in the New Hampshire Stormwater Manual (NHDES, 2008). To support the conceptual BMP development, Town soils data from past septic system permit applications at multiple locations across the subdivision was used to provide a screening-level assessment of subsurface soil properties. These test results included data on soil type and characteristics, depth to the seasonal high water table (SHWT) groundwater, and infiltration rate (in minutes per inch).

While the entire Subdivision is characterized by HSG Type B soils, the site-specific soils data varied significantly from area to area. The depth to SHWT varied between 5 and 144 inches with an average of about 36 inches. The measured infiltration rate varied between 2 and 61 minutes per inch, with an average of about 12 minutes per inch.

A land cover dataset was developed for the subdivision using Town GIS data, surveyed roadway limits and surface type, and aerial imagery. This dataset includes forest, lawn, building, driveways, paved, and unpaved road land cover classifications. The existing conditions land cover is shown in **Figure 3-2**.

3.1.4. Drainage Basin Delineation

Drainage basin delineation was performed using the topographic and stormwater conveyance data collected by Hancock. The 57-acre Subdivision was delineated into 13 sub-catchments, shown in **Figure 3-3.**

3.2. Existing Conditions Pollutant Loading

Land-use based water quality modeling was performed to establish the baseline pollutant loading rates from the Subdivision under existing condition. This method of pollutant loading analysis is commonly referred to as “washoff modeling”, which was used in both the 2008 WBP and the 2011 TMDL for Baboosic Lake. This analysis provided the basis for the stormwater drainage improvement recommendations described later in this study.

3.2.1. Washoff Model Selection

Pollutant washoff modeling assumes that during a given storm event, the concentration of pollutants in the stormwater runoff (referred to as event mean concentration, or EMC) is a function of the land uses or cover types that make up a given catchment. For instance, runoff from manicured lawns tend to contribute high levels of nutrients (from excess fertilizer), while industrial areas tend to contribute high levels of heavy metals (from machinery, gas combustion, etc). Many different methods for washoff modeling are available, each of which uses a slightly different ensemble of land use classifications and corresponding EMCs. The 2008 WBP, 2011 TMDL, and the New Hampshire MS4 permit all utilize different washoff models to predict pollutant loading based on watershed land use characteristics.

This drainage study employs the New Hampshire Simple method described in Volume 1 of the New Hampshire Stormwater Manual (NHDES, 2008). The Simple method produces estimates for three common urban runoff pollutants: total suspended solids (TSS), total nitrogen (TN), and TP. A spreadsheet version of the Simple method is published by the NHDES for use in land development applications and includes EMCs for land cover types included in the Subdivision land cover dataset except for gravel roads. As sediment runoff has been identified as a major nuisance issue for existing Subdivision, the model spreadsheet was updated to include EMCs for gravel roads. Here, the EMC for TSS was adopted from literature values for sediment washoff from gravel logging roads, while the TP and TN EMCs were assumed to match those for paved residential roads (Sheridan & Noske, 2007). **Table 3-1** below presents the EMCs applied for each pollutant and land cover type in the washoff analysis for this study, the extents of which are indicated on **Figure 3-3**.

Table 3-1. Land Cover EMCs Used in Washoff Analysis

Land Cover Type	Simple Model Event Mean Concentration, mg/L		
	TSS	TP	TN
Residential Roof	19	0.11	1.50
Residential Street (Paved)	172	0.55	1.40
Residential Street (Unpaved)	496	0.55	1.40
Lawns	80	2.10	9.10
Driveways	173	0.56	2.10
Forest/Rural Open	51	0.11	1.74

3.2.2. Pollutant Washoff Analysis Results

The results of the existing conditions pollutant washoff modeling conducted for this study are presented by subbasin in **Figures 3-4, 3-5, and 3-6** for TSS, TP, and TN; respectively. In these figures, each subbasin is color-shaded based on area-normalized pollutant loading rate. The results by subbasin are also presented in **Table 3-2**. Washoff model spreadsheet printouts are provided as **Appendix D** of this report.

The washoff rates reflected in **Figures 3-4 through 3-6** emphasize the loading “hot spots” in the Subdivision for each pollutant. Suspended solids are contributed most heavily by the Miriam, Mayhew, Rennie, and Longa subbasins due to the unpaved roads that serve these portions of the Subdivision. This was confirmed by observations made during the April 2022 site visit, in which sediment-laden runoff streams were evident downstream of these roads. The nutrient pollutants (TN and TP) are contributed most heavily by the Carter, Arnold, Mayhew and Miriam subbasins due to the higher proportion of landscaping and lawns (typically subjected to homeowner fertilizer use).

The washoff analysis predicted that the Pine Knoll Shore drainage basin contributes approximately 26 pounds of TP to Baboosic Lake per year. This prediction is reasonable when compared to the TP loading rates of 38.1 lb/yr estimated in the 2011 TMDL study and 64 lb/yr estimated in the 2008 WBP for a 240-acre watershed that included the Subdivision. The 57-acre Pine Knoll Shores drainage basin accounts for about a quarter of that larger watershed but about half of the population. Pine Knoll Shores is a densely populated portion of the larger TMDL watershed; and as TP is primarily generated by man-made source such as septic systems, fertilizer, and pet waste, the results of this drainage study are in line with the previous studies conducted for Baboosic Lake.

Table 3-2. Existing Condition Pollutant Washoff Model Results

Drainage Basin	Size, Ac.	TSS Pollutant Washoff Loading		TP Pollutant Washoff Loading		TN Pollutant Washoff Loading	
		Total, lb/yr	Area-Normalized, lb/ac/yr	Total, lb/yr	Area-Normalized, lb/ac/yr	Total, lb/yr	Area-Normalized, lb/ac/yr
Arnold	2.57	397	155	0.9	0.35	6.3	2.44
Carter-East	3.69	650	176	2.6	0.69	12.6	3.40
Carter-West	1.35	440	325	1.4	1.06	6.3	4.63
Lake-North	12.27	2,064	168	4.3	0.35	28.6	2.33
Lake-South	11.20	1,381	123	3.7	0.33	25.2	2.25
Longa	3.67	1,701	464	2.4	0.65	10.2	2.77
Mayhew-East	1.72	841	489	1.3	0.76	5.4	3.16
Mayhew-West	0.65	536	831	0.6	0.96	2.0	3.16
Miriam	2.22	1,579	710	2.2	1.01	8.6	3.88
Rennie-North	0.36	224	623	0.3	0.92	1.4	3.78
Rennie-South	1.49	528	355	0.8	0.52	3.9	2.65
Richards	9.54	679	71	1.6	0.17	12.2	1.28
Shore	6.28	1,469	234	3.7	0.59	18.3	2.92
Total	**57.01**	**12,489**	**219**	**25.9**	**0.45**	**141.04**	**2.47**

4. Proposed Drainage Improvement Projects

The purpose of this drainage study is to propose stormwater and infrastructure improvements that will reduce pollutant loading to Baboosic Lake and improve the roadway and drainage infrastructure serving the Subdivision. This section recommends specific projects to meet these goals driven by the potential pollutant loading reductions. Project cost and implementation considerations are also discussed based on discussions with the Town and NHDES. The projects proposed here will help the Town meet its requirements under the NH MS4 permit and reduce the phosphorous loading to Baboosic Lake from the Subdivision.

4.1. Project Development Approach

The selection of stormwater and roadway improvement projects were driven primarily by the potential for pollutant loading reductions. As all proposed projects must be sited within existing ROW or on Town-owned land, BMP sizing is based on the principle of achieving the maximum benefits practicable rather than meeting specific development design requirements. As shown in the existing condition washoff analysis, unpaved roadways in the Subdivision currently contribute significant TSS loading to Baboosic Lake. Based on this analysis and in consultation with DPW, it is agreed that the paving of subdivision roads combined with drainage infrastructure improvements will yield significant pollutant reductions while improving the quality of life for Subdivision residents. Siting stormwater BMPs within municipal ROWs can be challenging due to space limitations, and the amount of treatment feasible in these small footprints. The vacant town-owned parcels on Richard Road, Mayhew Road, and Miriam Road offer opportunities for regional-scale BMPs that can treat stormwater runoff from larger contributing drainage areas. While the Town owns several other parcels within the subdivision, these were not selected for consideration due to their location or size relative to stormwater conveyance lines or the contributing drainage area. Therefore, this study recommends a combination of both localized and regional BMPs to maximize the use of limited ROW space while taking advantage of the larger Town parcels for larger, cost-effective implementations. The installation of these BMPs can “piggyback” onto the construction of roadway and drainage improvements to minimize cost and mobilizations required for construction. Other factors considered in project development included abutter impacts, funding mechanisms, external funding eligibility, costs of construction, operation and maintenance, and traffic safety.

In short, the conceptual design for Subdivision stormwater improvements followed a three-step approach:

1. Pave the older and unpaved roadways of the subdivision.
2. Improve stormwater drainage infrastructure to drain the newly paved surfaces.
3. Treat the stormwater runoff from the Subdivision to the extent practicable to reduce pollutant loading to Baboosic Lake.

In coordination with the Town DPW and the NHDES, this approach was used to develop the stormwater improvement projects described in **Section 4.2.** Potential pollutant loading reductions for each proposed project is discussed in **Sections 4.3,** and proposed project implementation phasing is discussed in **Section 4.4**.

4.2. Proposed Stormwater Improvement Projects

Six individual stormwater improvement projects are proposed for the Subdivision in this drainage study. As described in **Section 4.1**, the development of these projects was primarily driven by pollutant loading reduction potentials and the availability of Town-owned land. The preliminary design concepts for each proposed project are shown in Conceptual Design Package, included in this report as Sheets C-1 through C-7 of **Appendix C**. The stormwater treatment BMPs proposed here should be designed per the guidelines listed in Volume 2 of the New Hampshire Stormwater Manual (NHDES, 2008) to the extent practicable. These six projects are:

- Roadway paving and drainage improvement

- Tree box filters and pocket bioretention cells
- Hydrodynamic Separators
- Bioretention cell at 5 Richards Road
- Stormwater Wetlands at 12 Mayhew Road
- Stormwater Park at 18 Miriam Road

Table 4-1 below qualitatively compares the key attributes of the six projects listed above.

Table 4-1. Project Comparison and Summary Matrix

Project	Pollutant Removal			Cost	Abutter Impact	Community Benefit	Maintenance	External Funding Eligibility
	TSS	TP	TN					
Roadway Paving & Drainage Improvements	Excellent	Fair	Fair	Poor	Fair	Excellent	Excellent	Good
Tree Box Filters	Excellent	Excellent	Excellent	Poor	Very Good	Very Good	Very Good	Excellent
Hydrodynamic Separators	Very Good	X	X	Very Good	Excellent	Good	Fair	Very Good
Bioretention at 5 Richard Road	Good	Good	Good	Very Good	Very Good	Good	Good	Excellent
Stormwater Wetlands at 12 Mayhew Road	Very Good	Very Good	Very Good	Very Good	Good	Good	Good	Excellent
Stormwater Park at 18 Miriam Road	Very Good	Excellent	Very Good	Good	Good	Excellent	Fair	Excellent

KEY: Excellent (●), Very Good (◓), Good (○), Fair (red ◒), Poor (red ●), NA (X)

Potential funding sources for these projects may include the Town's Capital Improvement Fund, NHDES Section 319 Watershed Assistance grants, NHDES Section 604(b) Water Quality Planning grants, CWSRF Stormwater Construction loans, or other grant opportunities (e.g. the Mooseplate grant program).

4.2.1. Roadway Paving and Drainage Improvement

Description:

The subdivision's unpaved roads contribute a substantial amount of sediment to Baboosic Lake. Further, the majority of the Subdivision's paved roads (limited to Carter Road, Shore Drive, and the western portion of Longa Road) were classified as "poor condition" in the Town's 2021 PCI survey. To reduce pollutant loading, AECOM is recommending all unpaved roadways through the subdivision be paved and all paved roadways be re-constructed. The paving of these roads will also provide a quality-of-life improvement to the residents in the Subdivision.

As part of the pavement design for the Subdivision, the Town requested that AECOM include traffic safety and sight distance considerations into the consideration of restricting certain roads within the Subdivision to be one-way streets. Per Town specifications, new one-way roads have a minimum paved width of 24 feet, while new one-way roads have a minimum paved width of 16 feet. To improve traffic safety and optimize the flow of traffic through the subdivision, a preliminary roadway directionality alignment (including the use of one-way roads) is proposed, as shown in **Figure 4-1**. New traffic signage, including one-way indicators, turn restrictions, and stop signs, will be installed. A traffic assessment was conducted to support these recommendations, and is attached to this study as **Appendix E**.

As part of the proposed roadway improvements, stormwater conveyance infrastructure will be installed to carry runoff from the improved roads. To control abutter impact, subsurface drainage or grass-lined swales are proposed depending on the ROW width and yard frontage for each street. Additionally, grass-lined swales (where appropriate) can be sized to provide stormwater treatment through settling and filtration. Proposed stormwater conveyance implementations are shown in **Figure 4-2**. The proposed stormwater alignment for the new drainage system is further discussed in **Section 4.4.** It should be noted that both roadway surface improvements and the installation of vegetated swales were consistent with recommendations in the 2008 WBP. To maintain compliance with the Town's NH MS4 coverage, the final storm sewer system will be incorporated into the Town's storm drain mapping once completed.

Pollutant Reductions:

Roadway paving will reduce the sediment loading contributed by the current unpaved roadways by nearly a factor of three (see **Table 3-1**). Slight increases in nutrient contribution are expected due to the increased roadway footprint, but this loading increase will be mitigated by other stormwater treatment measures proposed in this study.

Vegetated swales are capable of removing TSS, TP, and TN from stormwater runoff at removal rates of 81%, 9%, and 38%, respectively (USEPA, 1999).

Costs:

Assuming Full Box Reconstruction will be utilized for all roads within the Subdivision and utilizing a $50/SY unit price for this method provided by the Town, the estimated roadway paving for the entire subdivision is approximately $1.6M. The cost for installation of stormwater drainage system and swales for the entire subdivision is approximately $703K.

Maintenance for the new roadways and drainages system in the Subdivision will follow the Town's general maintenance program, which includes winter plowing and material placement; spring sweeping; catch basin cleaning; line striping (as needed); patching and preventative maintenance (i.e., crack sealing), and roadside mowing and trimming.

4.2.2. Tree Box Filters & Pocket Bioretention Cells

Description:

Tree box filters (TBFs) are miniature bioretention cells, or rain gardens, built within a precast concrete structure that is connected to the stormwater conveyance network. **Figure 4-3** presents excerpts of plans and photos of a typical TBF unit manufactured by Contech Engineered Systems, Inc. (Contech). TBFs are typically planted with one tree or shrub and provide a low-footprint option for stormwater quality treatment. The units accept runoff from a curb inlet and allow stormwater to percolate through layers of mulch, loamy soil, and sand before either being taken up into the vegetation's root system or exiting through the unit's underdrain into the larger stormwater conveyance system. Each unit is sized to hold the water quality volume (WQV), with flows in exceedance of this volume collected by a catch basin just downstream of the TBF. In the Subdivision, TBFs are proposed along Carter Road, Shore Drive, and at the corner of Mayhew and Rennie Roads, positioned to take advantage of available space within the Town's ROW.

The proposed placement of TBFs within the subdivision is presented on **Figure 4-4**.

It should be noted that the installation of precast bioretention units was recommended both as a general watershed implementation and a site-specific drainage improvement within the Pine Knoll Shores Subdivision in the 2008 WBP. This implementation would be in line with that initial recommendation.

Pollutant Reductions:

TBFs are capable of removing TSS, TP, and TN from stormwater runoff at removal rates of 86%, 70%, and 34%, respectively (Contech, 2022).

Costs:

TBFs range in price from $16K to $19K per unit, including delivery. Each TBF would cost approximately $10K for installation.

TBFs require maintenance twice per year, and maintenance is limited to the removal of accumulated debris or litter, the removal and replacement of the surficial mulch layer, and plant pruning as required. The annual cost for this maintenance ranges between $600 - $1200 per unit if contracted out but can also be completed easily by Town maintenance staff. Contech anticipates the average lifespan of the trees and shrubs planted in the tree box units is between two and four years.

4.2.3. Hydrodynamic Separators

Description:

Hydrodynamic Separators are manhole treatment units that use the off-center introduction of flow to a structure and internal flow control weirs to induce a rotational vortex within the structure to remove TSS from stormwater runoff. Hydrodynamic separators are manufactured by a number of third-party vendors and can be placed in-line along conveyance systems to provide sediment removal from stormwater runoff. **Figure 4-5** shows a diagram of a typical hydrodynamic separator unit manufactured by Contech. One hydrodynamic separator is proposed for installation at the end of Carter Road as shown in **Figure 4-4**.

Pollutant Reductions:

Hydrodynamic separators can achieve TSS removal rates of 80% (Contech, 2017).

Costs:

Hydrodynamic separators cost approximately $10K - $12K per unit including delivery, depending on manufacturer and region. Installation for these structures is on the order of $5K.

Hydrodynamic separators require annual maintenance that involves removing the accumulated sediment and debris from the structure via vacuum truck. One unit takes 1-2 hours to clean out, and current day-rates for vacuum truck contractors is between $2K - $5K per day. This maintenance can be performed by Town staff using Town equipment as part of regular drainage maintenance program.

4.2.4. Bioretention Cell (Rain Garden) at 5 Richards Road

Description:

The Town-owned property at 5 Richards Road is approximately one-eighth of an acre in size. It is currently covered by dense brush and small trees. To provide water quality treatment for runoff coming from Richards Road and connected upstream areas, a bioretention cell is proposed to be constructed on the parcel. Bioretention cells, commonly referred to as rain gardens, filter pollutants from stormwater via percolation through layers of mulch, loamy soil, and sand before either being taken up into the root systems of the bioretention cell vegetation. Depending on the elevation of the SHWT, any remaining stormwater is either infiltrated into the native soils or drained back into the stormwater conveyance system using an underdrain. The bioretention cell will be sited within the parcel with a minimum 10-foot setback from abutting properties. Pretreatment is required through a sediment forebay (or similar) prior to treatment within the bioretention cell.

At 5 Richards Road, pretreatment would be provided through a sediment forebay placed near the roadway where runoff enters the property. Construction of the proposed bioretention cell will involve the clearing of debris, brush, and trees from the existing parcel. A berm will be installed on the parcel's downgradient end to prevent overflow onto the neighboring property. Trees and screening plants can be installed along the berm if desired. Runoff rates exceeding the cell's treatment capacity will be routed back to the conveyance system using grated standpipes (or similar) to control the cell's maximum ponding depth. A conceptual schematic of the proposed BMP is provided on Sheet D-2 of **Appendix C**. Based on nearby historic septic testing data, the SHWT in the area is around 25 inches below ground surface and the infiltration rate into native soils is about 9 minutes per inch (see sheet V-5 of **Appendix C**). These parameters should be field verified during the final design.

It should be noted that the bioretention cells were recommended as a general watershed improvement in the 2008 WBP.

Once installed, the O&M associated with bioretention cells includes biannual inspections and the repair or replacement of treatment area components as needed. Vegetation should be trimmed and diseased vegetation removed as appropriate. Mulch replacement is recommended when erosion of the bioretention cell bed becomes evident. Alkaline product can be applied as needed to counteract soil acidity caused by slightly acidic rainfall and runoff. (USEPA, 1999)

Pollutant Reductions:

Bioretention cells are capable of removing TSS, TP, and TN from stormwater runoff at removal rates of 95%, 65%, and 65%, respectively (NHDES, 2008).

Cost:

A preliminary estimate for the proposed bioretention cell at 5 Richards Road is approximately $52K. See **Appendix G** for a detailed cost breakdown for this project. O&M costs are expected to be comparable to those of typical landscaping required for a given site, but will vary based on the final design of the system.

4.2.5. Stormwater Wetlands at 12 Mayhew Road

Description:

The Town-owned property at 12 Mayhew Road is just over one-quarter of an acre in size and is currently forested with little underbrush. The parcel is located in a topographic low point, and standing water was observed on the property during the AECOM site visit. To provide water quality treatment for stormwater runoff draining from Mayhew Road, the installation of a pocket stormwater wetland is proposed for the parcel. Stormwater wetlands are constructed impoundments designed to function similar to natural wetlands and consist of pools with various depths to promote settling and native wetland vegetation growth. Pollutant removal is achieved through settling of sediments within the impoundment and nutrient uptake by vegetation. Stormwater wetlands typically require a shallow SHWT or a constant flow of water. The stormwater wetlands will be sited within the parcel with minimum 10-foot setback from abutting properties, and screening vegetation can be planted if desired. Pretreatment is required prior to treatment within the stormwater wetland and would be provided through a pretreatment swale running parallel to the newly paved Mayhew Road. A berm will be installed on the parcel's downgradient end to prevent overflow onto the neighboring property. Runoff exceeding the treatment capacity of the wetland will be routed to the conveyance system using grated standpipes (or similar). A conceptual schematic of the proposed BMP is provided on Sheet D-2 of **Appendix C**.

Based on nearby historic septic testing data, the SHWT in the area is around 25 inches below ground surface and the infiltration rate into native soils is 4-10 minutes per inch (see sheet V-04 of **Appendix C**). These parameters should be field verified during the final design.

Once the stormwater wetlands have been constructed, the planted vegetation must be maintained. Inspections should be conducted twice per year for the first three years and once annually every year thereafter, and include pruning, replacement planting, sediment and debris removal, and invasive species removal (as needed). (USEPA, 1999)

Pollutant Reductions:

Stormwater wetlands are capable of removing TSS, TP, and TN from stormwater runoff at removal rates of 80%, 55%, and 45%, respectively (NHDES, 2008).

Cost:

A preliminary estimate for the proposed stormwater wetland at 12 Mayhew Road is approximately $52K. See **Appendix G** for a detailed cost breakdown for this project. O&M costs are expected to be comparable to those of typical landscaping required for a given site, but will vary based on the final design of the system.

4.2.6. Stormwater Park at 18 Miriam Road

Description:

The property at 18 Miriam Road is just over one-half of an acre in size and is the largest Town-owned property in the Subdivision. The property consists of a relatively flat, upland clearing on its eastern end; a steep hillslope in the center; and a gently sloping forested lowland area on its western end. Remnants of a wellhead or septic system are present in the upland clearing. Standing water was observed on the western end of the property during the AECOM site visit. To provide water quality treatment for stormwater runoff coming from Miriam Road and to provide an opportunity for community outreach, a multi-functional "Stormwater Park" is proposed on the parcel consisting of bioretention cells, stormwater wetlands, walking trails, and educational signage.

A conceptual schematic of the proposed stormwater park layout is provided on Sheet D-2 of **Appendix C**. In this conceptual design, three bioretention cells would be placed on the upland portion of the site. Runoff would be directed to these cells from the Miriam Road drainage system using flow diversion structures that direct only low flows towards the park while bypassing larger flows towards the Carter Road outfall. Pretreatment would be provided by sediment forebays. Overflow from the bioretention cells would cascade down the hillslope into constructed pocket wetlands located in the lowlands portion of the site. Overflow from the stormwater wetland would be routed back to the conveyance system using grated standpipes (or similar) used to control the ponding depth. To limit abutter impacts, a minimum 10-foot setback from parcel lines will be used, and screening vegetation can be planted if needed. A berm will be installed on the parcel's downgradient end to prevent stormwater "overflow" the neighboring property. Walking trails will be constructed to weave around the proposed BMPs, paired with educational signage.

Based on historic septic testing data conducted on the uplands portion of the property, the SHWT is about 12 feet below ground surface and the infiltration rate into native soils is 25 minutes per inch (see sheet V-3 of **Appendix C**). These parameters must be field verified during detailed design.

It should be noted that the installation of bioretention cells were recommended as a general watershed improvement in the 2008 WBP. Further, both the WBP and New Hampshire MS4 permit recommend or contain provisions for public education and outreach to improve awareness of stormwater management, and this implementation meet requirements for public outreach and education under the 2018 Notice of Intent (NOI) for coverage under the NH MS4 (Town of Merrimack, 2019). The required post-construction O&M for the bioretention cells and stormwater wetlands are listed in **Sections 4.2.4 and 4.2.5** of this report, respectively.

Pollutant Reductions:

The pollutant removal capacities of bioretention cells and stormwater wetlands are described previously in **Sections 4.2.4 and 4.2.5** of this report, respectively.

Cost:

The preliminary estimate for the proposed stormwater park at 18 Miriam Road is approximately $162K. See **Appendix G** for a detailed cost breakdown for this project. O&M costs are expected to be comparable to those of typical landscaping required for a given site, but will vary based on the final design of the park.

4.3. Pollutant Reduction Summary

Pollutant reductions for the proposed condition were calculated using the washoff model described in **Section 3.2** with updated land cover and the proposed stormwater BMPs. The proposed condition land coverage is shown in **Figure 4-6** and reflects the proposed roadway paving. The results of the proposed conditions pollutant loading are presented in **Figures 4-7, 4-8, and 4-9** for TSS, TP, and TN; respectively. With the road surface conversion, a significant reduction in TSS loading can be achieved (**Figure 4-7**)**.** The pollutant loading rates by subbasin are summarized in **Table 4-2**. **Table 4-3** summarizes the pollutant reductions associated with each stormwater improvement project described above. The washoff model calculation spreadsheets are provided as **Appendix D** of this report.

Table 4-2. Proposed Condition Pollutant Washoff Model Results

Drainage Basin	Size, Ac.	TSS Pollutant Washoff Loading			TP Pollutant Washoff Loading			TN Pollutant Washoff Loading		
		Total, lb/yr	Area-Normalized, lb/ac/yr	Reduction from Existing, %	Total, lb/yr	Area-Normalized, lb/ac/yr	Reduction from Existing, %	Total, lb/yr	Area-Normalized, lb/ac/yr	Reduction from Existing, %
Arnold	2.57	217	84	45%	1.0	0.37	-5%	6.4	2.49	-2%
Carter-East	3.69	110	30	83%	2.0	0.54	22%	4.1	1.11	67%
Carter-West	1.35	93	69	79%	1.6	1.17	-10%	6.6	4.88	-5%
Lake-North	12.27	1,530	125	26%	4.8	0.39	-11%	29.7	2.42	-4%
Lake-South	11.20	1,240	111	10%	4.5	0.41	-22%	27.2	2.43	-8%
Longa	3.67	114	31	93%	1.3	0.37	44%	8.7	2.39	14%
Mayhew-East	1.72	66	38	92%	0.6	0.34	55%	3.0	1.74	45%
Mayhew-West	0.65	30	46	94%	0.4	0.69	28%	0.7	1.01	68%
Miriam	2.22	60	27	96%	0.8	0.35	65%	3.0	1.36	65%
Rennie-North	0.36	13	36	94%	0.2	0.65	29%	0.4	1.18	69%
Rennie-South	1.49	30	20	94%	0.5	0.34	34%	1.2	0.79	70%
Richards	9.54	410	43	40%	1.6	0.17	-1%	12.3	1.29	0%
Shore	6.28	706	112	52%	3.3	0.53	10%	12.4	1.97	32%
Total	**57.01**	**4,681**	**81**	**63%**	**22.7**	**0.40**	**12%**	**115.7**	**2.03**	**18%**

Table 4-3. Pollutant Loading Reductions by Stormwater Improvement Projects

Proposed Stormwater Improvement Project*	Drainage Basins Served	TSS Removals, lb/yr	TP Removals, lb/yr	TN Removals, lb/yr
Roadway& Drainage: Paving	All	4,552	-2.1**	-5.1**
Roadway & Drainage: Vegetated Swales	Longa	486	0.8	0.9
Tree Box Filters	Carter-East, Rennie-North, Rennie-South, Mayhew-West, Shore	1,551	2.2	20.2
Hydrodynamic Separators	Carter-West	373	0	0
5 Richards Road Bioretention Cell	Shore	106	0.14	1.3
12 Mayhew Road Stormwater Wetland	Mayhew-East	264	0.7	2.4
18 Miriam Road Stormwater Park	Miriam	539	1.5	5.6

**Stormwater BMP loading reductions reflect pollutant removals from the proposed condition land cover (paved roads). Roadway paving loading reductions reflect land cover changes alone.*

***Negative removals indicate an increase in pollutant contribution attributable to a wider roadway surface.*

The project-specific loading results presented in **Table 4-3** indicate that roadway paving by far accounts the most reductions in TSS loading, with slight increases in nutrient loading due to the overall increase in road surfaces counteracted by the implementation of the proposed stormwater treatment BMPs. Of the stormwater treatment BMPs considered, the tree box filters proposed along Carter Road, Rennie Road, and Shore Drive collectively provide the most removals of TSS and nutrients.

4.4. Stormwater Conveyance

A stormwater conveyance analysis was performed to estimate of the pipe sizes for the drainage system serving the paved roads proposed in the Subdivision. According to communications with DPW, all existing conduit serving the Carter Road outfall will be replaced, and all new conduit will be made of high-density polyethylene (HDPE). New, proposed drainage pipes will have a minimum inner diameter of at least 12 inches with at least four feet of cover. The design storm for subdivision stormwater conveyance systems in the Town of Merrimack is the 25-year (4% annual recurrence), 24-hour duration, a total depth of 5.46 inches (NRCC, 2022). To account for potential increases in extreme rainfall events due to climate change, an additional 15% increase in rainfall depth has been added to the Town design storm, following guidance from the New Hampshire Coastal Risks and Hazards Commission (NHCRHC, 2014). This increase brings the final stormwater conveyance design 25-year, 24-hour rainfall total to 6.28 inches.

4.4.1. Proposed Stormwater Routing Alignment

As previously discussed in this report, two stormwater outfalls drain the Subdivision and discharge conveyance to Baboosic Lake: an NH MS4 outfall at the end of Carter Road, and a smaller outfall on Shore Drive not included in the Town's NH MS4 permit. The Shore Drive outfall discharges into a small asphalt-lined swale adjacent the driveway of 20 Shore Drive which is located on a private lake-access easement collectively owned by the residents of the Subdivision. The asphalt-lined ditch discharges onto the yard downgradient of the driveway and eventually into Baboosic Lake. The homeowner of 20 Shore Drive has reported this outfall to be a source of nuisance flooding, causing erosion of a retaining wall and flooding in the building's basement (Town of Merrimack DPW, 2022). The total drainage area contributing to the Shore Drive outfall is currently about 23.3 acres (**Figure 4-10)**. The Carter Road outfall is currently a 12-inch CMP serves drains about 8.0 acres of the Subdivision.

The stormwater conveyance network proposed to drain the newly paved subdivision roads is shown in **Figure 4-11**. The proposed network would redirect the stormwater runoff from the newly paved Longa, Mayhew, and Rennie Roads north towards the Carter Road outfall. This configuration would reduce the contributing drainage area towards the Shore Drive outfall by approximately 75% to 6.3 acres, which is expected to alleviate the flooding conditions at this outfall near 20 Shore Drive.

4.4.2. Conveyance System Analysis and Recommendations

Hydraulic analysis in support of the proposed drainage conveyance system sizing was performed using the HydroCAD (Ver 10.10-6a) stormwater model. As described in **Section 4.4**, the hydraulic design criterion for the proposed system is the 24-hour duration storm with a 25-year (4% annual chance) return interval with a 15% adjusted increase to account for potential increases in extreme rainfall events due to climate change advised by NHCRHC. The HydroCAD stormwater model reports and detailed results are provided in **Appendix F-1**. The hydraulic analysis was used to determine the peak flow rates that the proposed system would convey, and simple engineering calculations (**Appendix F-2**) were used to determine that the existing Carter Road outfall had insufficient capacity to meet this demand. The HydroCAD model was then used to size the proposed conveyance system.

Under the proposed condition, the Carter Road Outfall would be upgraded to an 18-inch HDPE pipe to accommodate the additional flow. The proposed conveyance system is shown in Sheets C-1 through C-7 of **Appendix C.** In the detailed design, the engineer is advised to consider end-of-pipe stabilization measures, such as energy dissipation pads and channel armoring at the point of discharge to protect the banks of Baboosic Lake within the Town drainage easement.

4.5. Project Implementation and Phasing

Formulating an implementation plan must balance project benefits and constraints. The six projects recommended by this study are primarily driven by pollutant loading reduction. As the analysis showed, roadway paving achieves the most reductions in TSS loading while also improving the quality of life for the residents. From the perspective of stormwater conveyance, the Carter Road outfall and the main “trunk” drainage line beneath Carter Road should be upgraded first to provide adequate hydraulic capacity at the downstream end as the other projects are implemented over time. As the Pine Knoll Shores Subdivision is an established community, construction planning should attempt to minimizing abutter impact through active stakeholder outreach.

For the most part, the Town finances stormwater maintenance and improvement projects through the DPW’s general fund. Various external grant and loan programs are available to potentially fund the projects proposed in this study, which may result in variable phasing or grouping scenarios. Based on discussion with the DPW, this section outlines a phasing plan to implement the projects proposed in this study. As illustrated in **Figure 4-12**, this plan groups the projects in 4 phases, with the estimated cost and pollutant loading reductions for each phase summarized in **Table 4-4**. A more detailed breakdown of estimated project cost is provided in **Appendix G.**

Phase 1 includes improvements along Carter Road, including roadway reconstruction, stormwater conveyance, hydrodynamic separator installation, tree box filter installation, and outfall channel stabilization. Carter road is the first portion of the Subdivision to be upgraded as it will hold the primary “trunk” drainage line that will eventually serve Miriam, Rennie, Mayhew, Arnold, and Longa Roads.

Phase 2A includes improvements along Miriam, Thomas, and Arnold Roads, including roadway paving, stormwater conveyance, and the development of the stormwater park at 18 Miriam Road. The Miriam drainage basin was identified in the existing conditions washoff analysis as the second-highest source of TP and TN loading to the Lake (see **Section 3.2.2**), and so the area is prioritized for implementation over the other portions of the Subdivision. Stormwater conveyance from this Phase will connect to the Carter Road trunk line at the intersection of Arnold and Carter Roads.

Phase 2B includes improvements along Mayhew, Longa, and Rennie Roads, including roadway paving, stormwater conveyance, tree box filter installation, and the development of the stormwater wetland at 12 Mayhew Road. Stormwater conveyance from this Phase will connect to the Carter Road trunk line at the intersection of Rennie and Carter Roads.

Phase 3 includes improvements along Longa, Richards, and Donald Roads, as well as Shore Drive; and includes roadway paving, tree box filter installation, the development of the bioretention cell at 5 Richards Road, and minimal stormwater conveyance work. No changes to the routing of the Shore Drive stormwater collection system are proposed.

Table 4-4. Proposed Stormwater Improvement Implementation Phasing

Implementation Phase	Estimated Cost*	Annual TSS Loading Reduction, lb/yr	Annual TP Loading Reduction, lb/yr	Annual TN Loading Reduction, lb/yr
Phase 1	$926,937	1,098	0.5	9.0
Phase 2A	$777,769	2,234	0.9	4.4
Phase 2B	$655,331	3,366	2.2	8.0
Phase 3	$560,513	905	-0.4	4.0
Total	**$2,920,550**	**7,603**	**3.2**	**25.4**

**See Appendix G for a detailed cost breakdown*

4.6. Permitting Implications

The projects proposed in this study will meet one or more of the requirements set forth in the current 2017 (and likely future) 2017 NH MS4 permit and will contribute to the goal of alleviating the phosphorus impairment of Baboosic Lake. It is important to note that the final project design and construction will be subject to the rules and regulations of the Town of Merrimack, the state of New Hampshire, and the federal government, as applicable. For work involving wetlands or other jurisdictional waters, such as the stabilization of the drainage channel downstream of the Carter Road outfall, the Merrimack Conservation Commission and New Hampshire Wetlands Bureau may need to be engaged. A NHDES shoreland permit may also be required for work along the banks of the Lake. All wetlands should be field delineated by qualified wetlands specialists prior to detailed design. The proposed projects may be subject to regulation by the NHDES Alteration of Terrain Bureau, if the final design exceeds the land disturbance thresholds set forth by the Bureau. The final design will apply erosion control measures per Volume 3 of the New Hampshire Stormwater Manual, the New Hampshire Construction General Permit, and the Town of Merrimack’s Erosion and Sediment Control Regulations (NHDES, 2008). In addition, certain federal permits may be required to complete the work, including (but not limited to) the Construction General Permit, Army Corps of Engineers wetlands permits, and others to be identified during the design phase.

5. Conclusions

The Baboosic Lake Drainage Study was performed under funding made available by the NHDES CWSRF loan program. Its objective is to reduce the TP loading in the stormwater runoff from the Subdivision through the development of stormwater BMPs with measurable pollutant reduction performance. Using a water quality washoff model, a pollutant loading baseline for the Subdivision was established and used as the basis to develop stormwater drainage, conveyance, and treatment projects within the Town's existing ROW and Town-owned parcels through the Subdivision. The recommended projects, if implemented in a timely manner, are expected to reduce TSS, TP, and TN loading to the Baboosic Lake from a highly developed TMDL watershed.

6. References

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7. Figures

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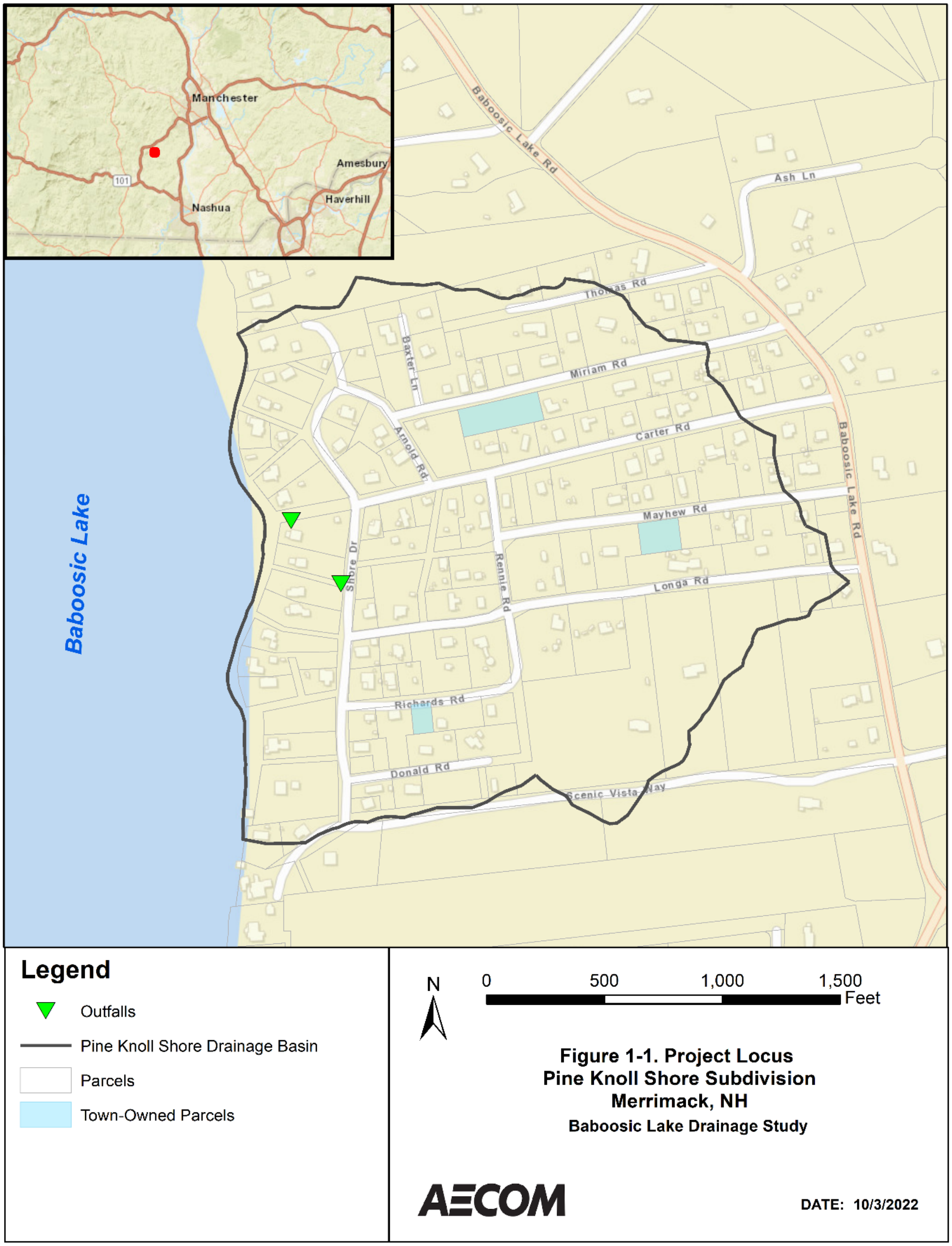
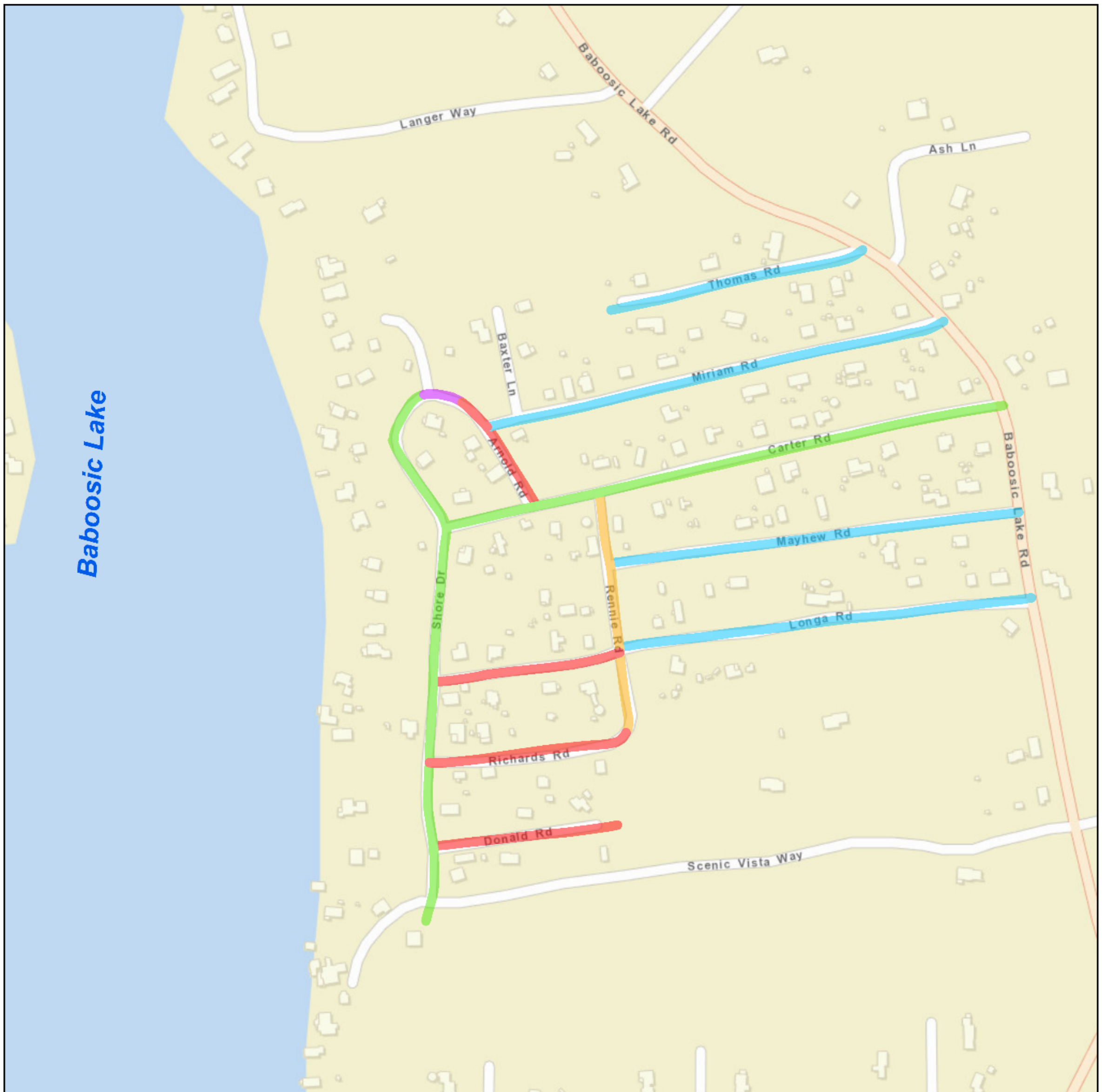


Figure 1-1. Project Locus
Pine Knoll Shore Subdivision
Merrimack, NH
Baboosic Lake Drainage Study

AECOM

DATE: 10/3/2022



Legend

Town ROW Width

- 15 Feet
- 20 Feet
- 25 Feet
- 30 Feet
- 40 Feet

N

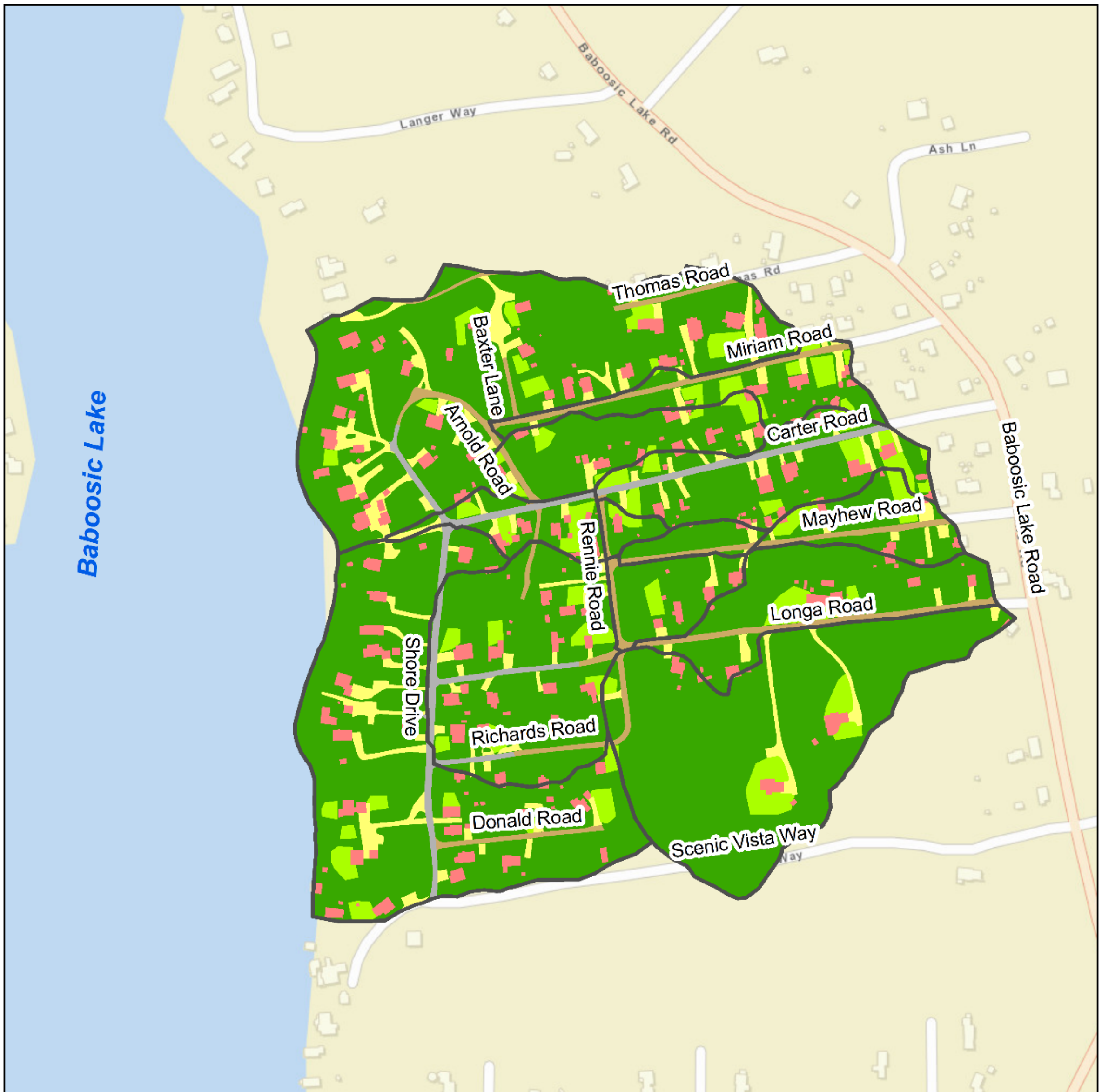
0 500 1,000 1,500 Feet

Figure 3-1. Town Right-of-Way Widths

Baboosic Lake Drainage Study

AECOM

DATE: 9/20/2022



Legend

Drainage Areas

Existing Condition Land Cover

- Building
- Gravel Road
- Driveway
- Forest / Open
- Lawn
- Paved Road

N

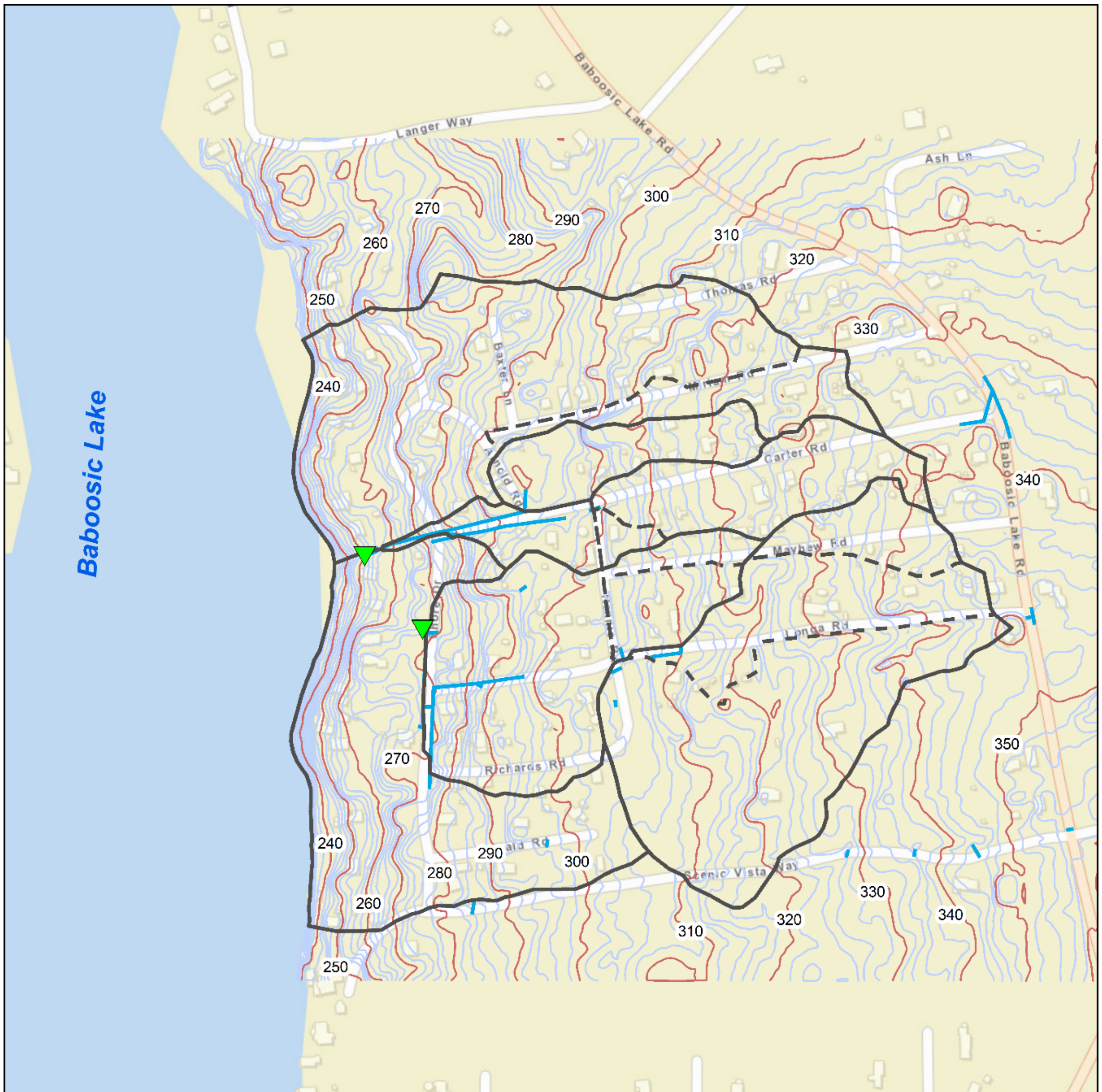
0 500 1,000 1,500 Feet

Figure 3-2. Existing Condition Land Cover

Baboosic Lake Drainage Study

AECOM

DATE: 10/3/2022



Legend

- Outfalls
- Ex. Drainage Delineation
- Pr. Drainage Delineation
- Surveyed Stormwater Conduit
- Minor Topo Contours (2')
- Major Topo Contours (10')

N

0 500 1,000 1,500 Feet

Figure 3-3. Drainage Basin Delineations

Baboosic Lake Drainage Study

AECOM

DATE: 10/3/2022

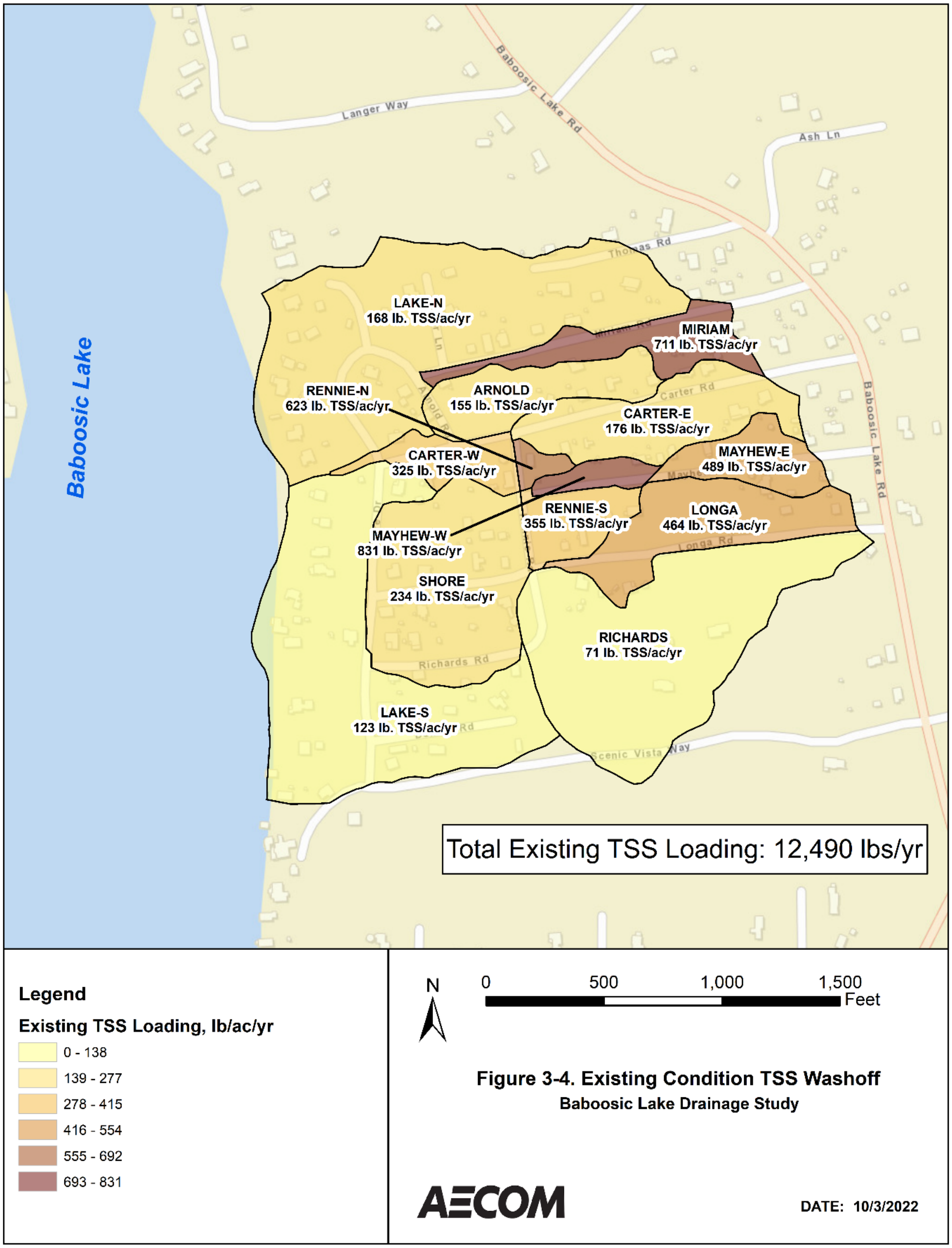


Figure 3-4. Existing Condition TSS Washoff
Baboosic Lake Drainage Study

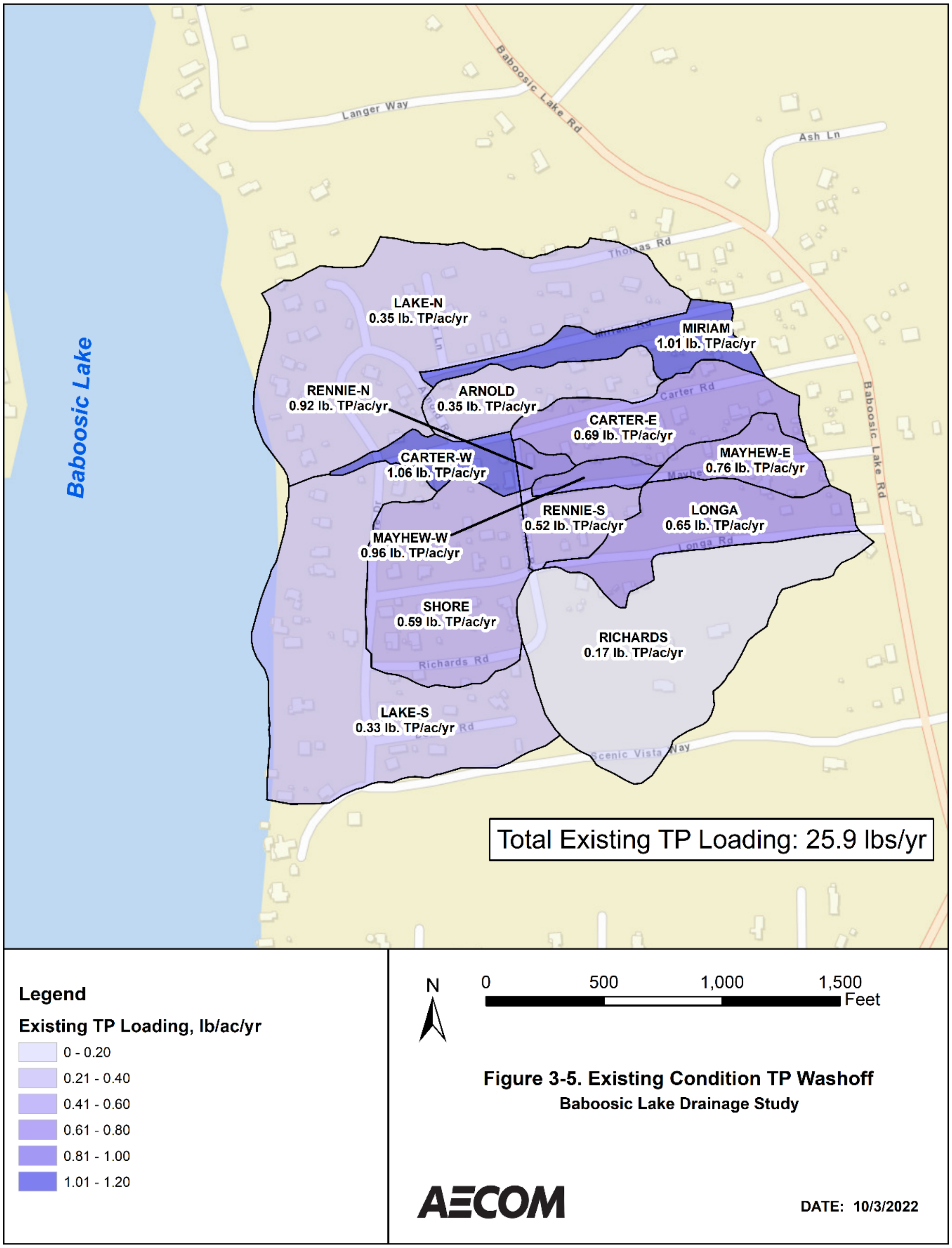


Figure 3-5. Existing Condition TP Washoff
Baboosic Lake Drainage Study

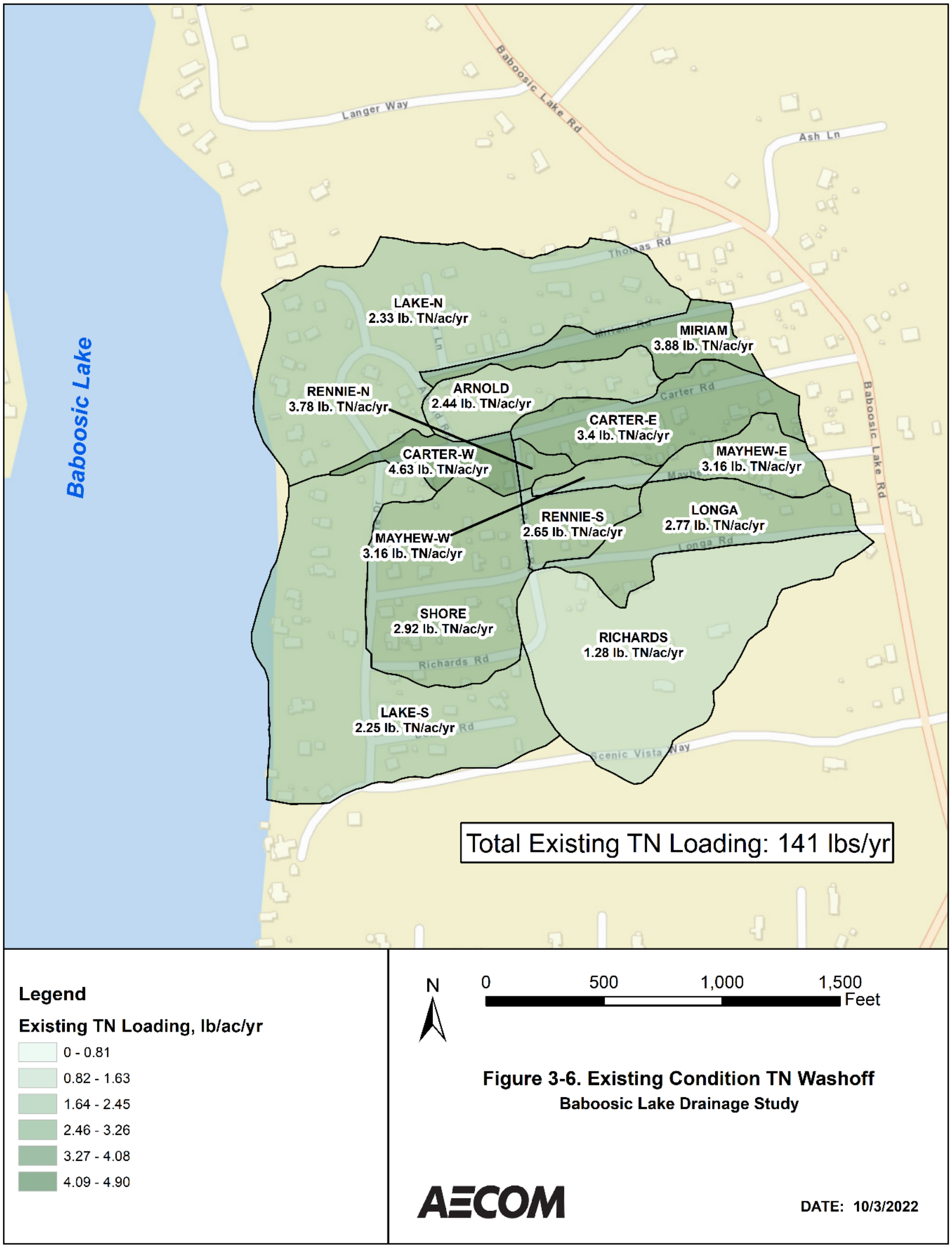
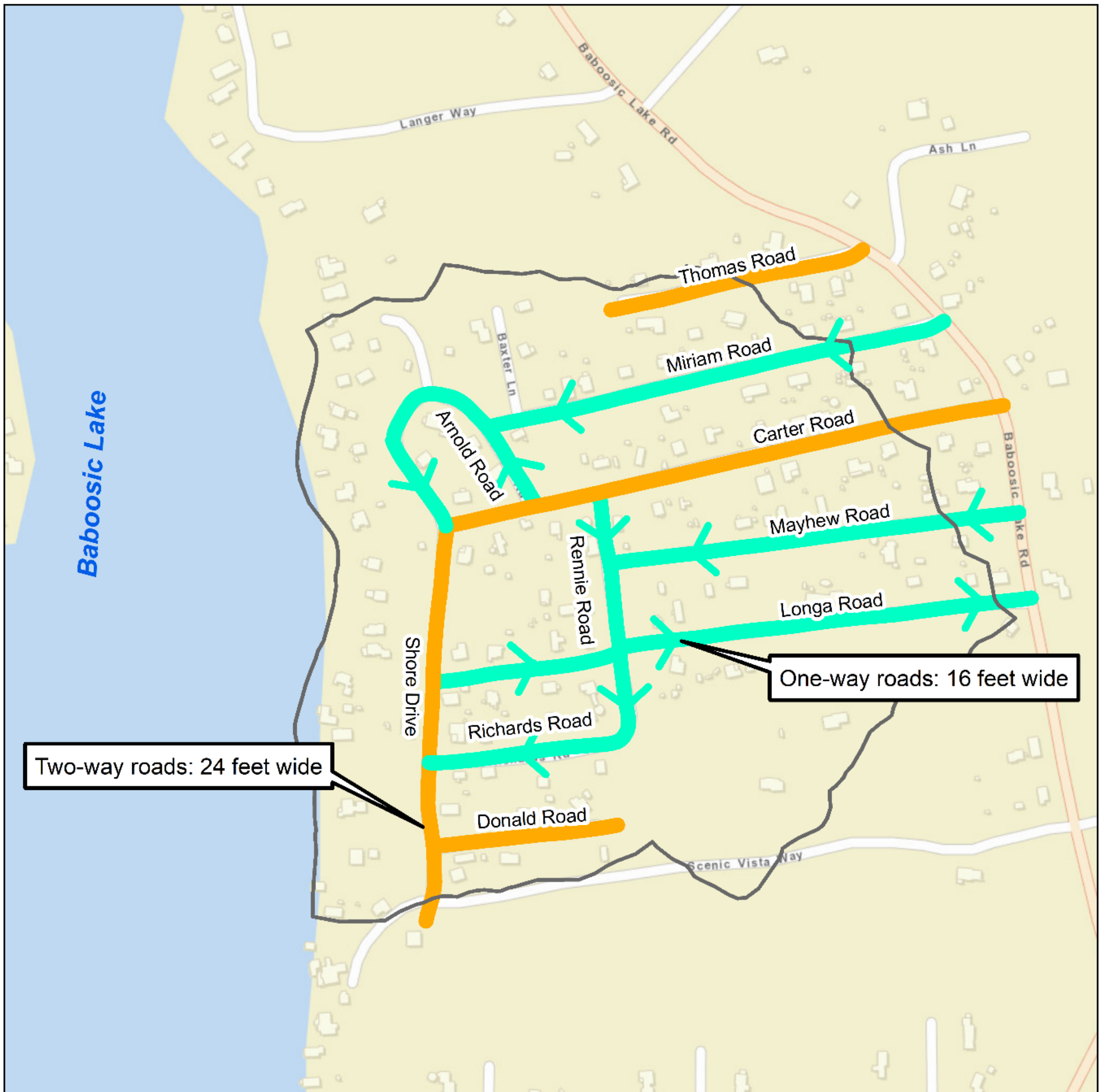


Figure 3-6. Existing Condition TN Washoff
Baboosic Lake Drainage Study



Legend

Watershed Limits

Proposed Directionality

Two-Way

One-Way

One-Way Traffic Direction

Note proposed roadway layout are preliminary and subject to change during detailed design.

N

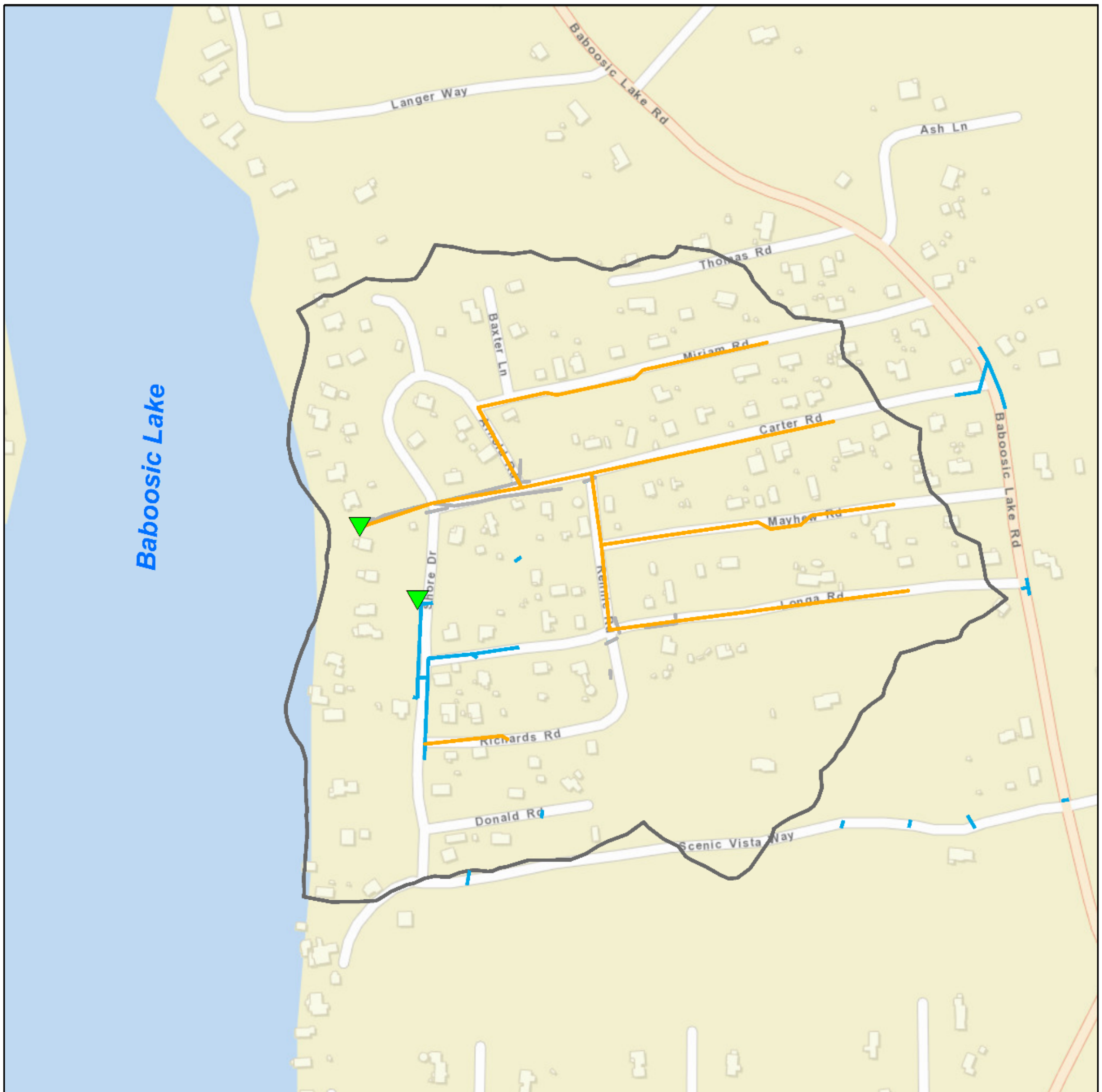
0 500 1,000 1,500 Feet

Figure 4-1. Proposed Road Directionality

Baboosic Lake Drainage Study

AECOM

DATE: 10/3/2022



Legend

- Outfalls
- Proposed Drainage Conduit
- Existing Drainage Conduit to Remove/Modify
- Existing Drainage Conduit to Remain
- Pine Knoll Shore Drainage Basin

Note drainage network are preliminary and subject to change during detailed design.

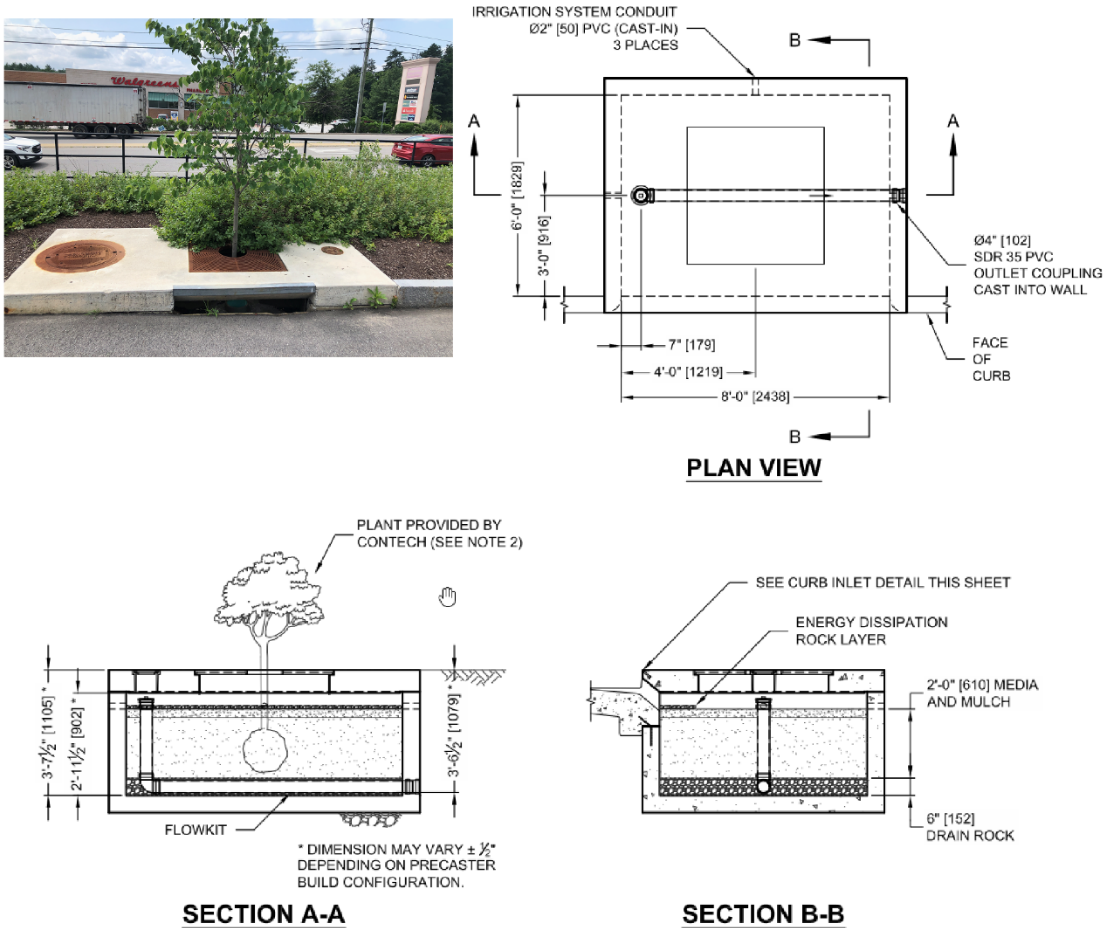
N

0 500 1,000 1,500 Feet

Figure 4-2. Proposed Conveyance Systems
Baboosic Lake Drainage Study

AECOM

DATE: 10/3/2022



TBFs proposed here will have external bypass for peak flow diversion, in the form of a catch basin located immediately gowngradient of the structure. Contech Filterra Offline Standard Model No. FT0806 shown here as a sample. Other models and manufacturers of tree box filters are available.

Figure 4-3. Tree Box Filter Details

Baboosic Lake Drainage Study

AECOM

DATE: 11/9/2022

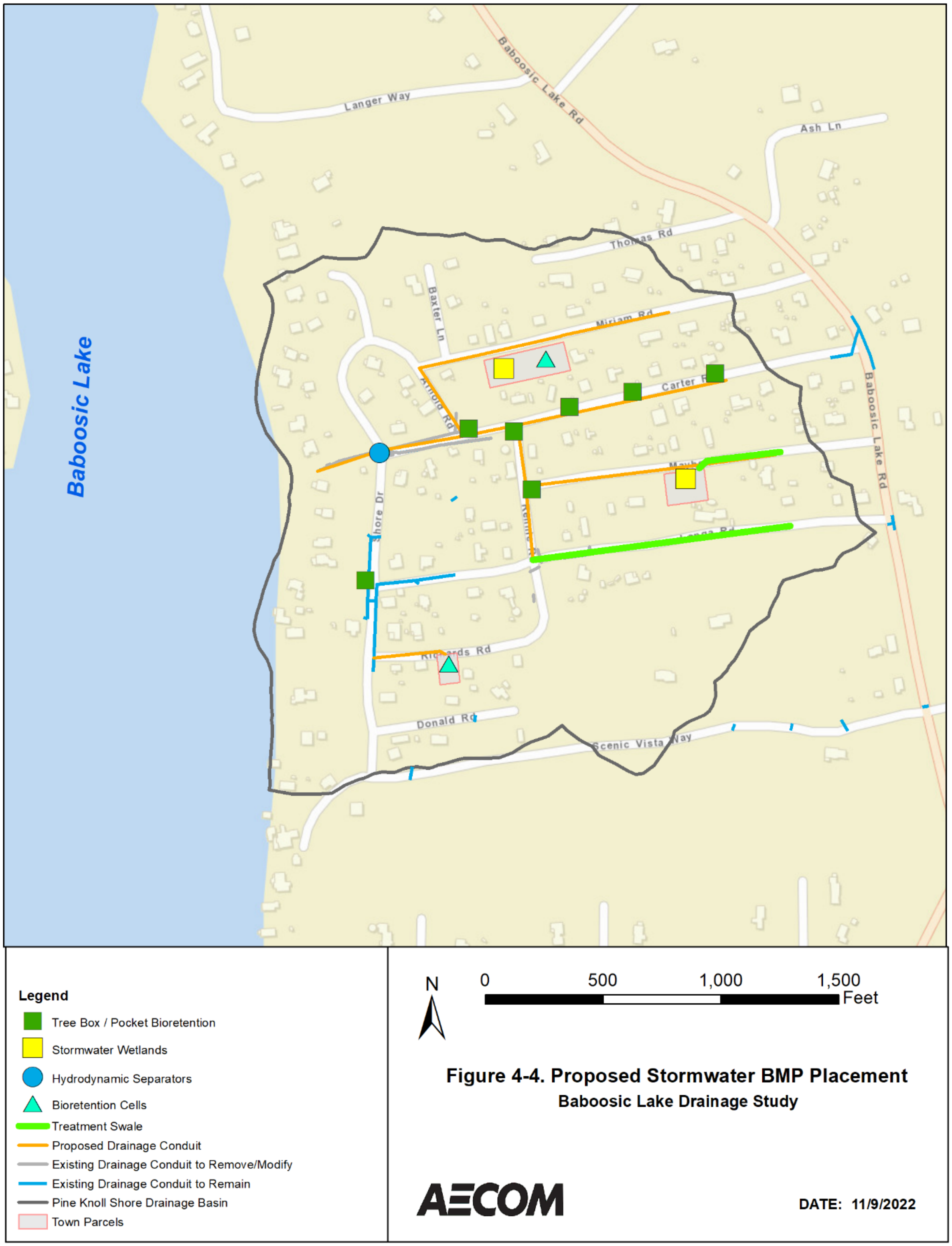
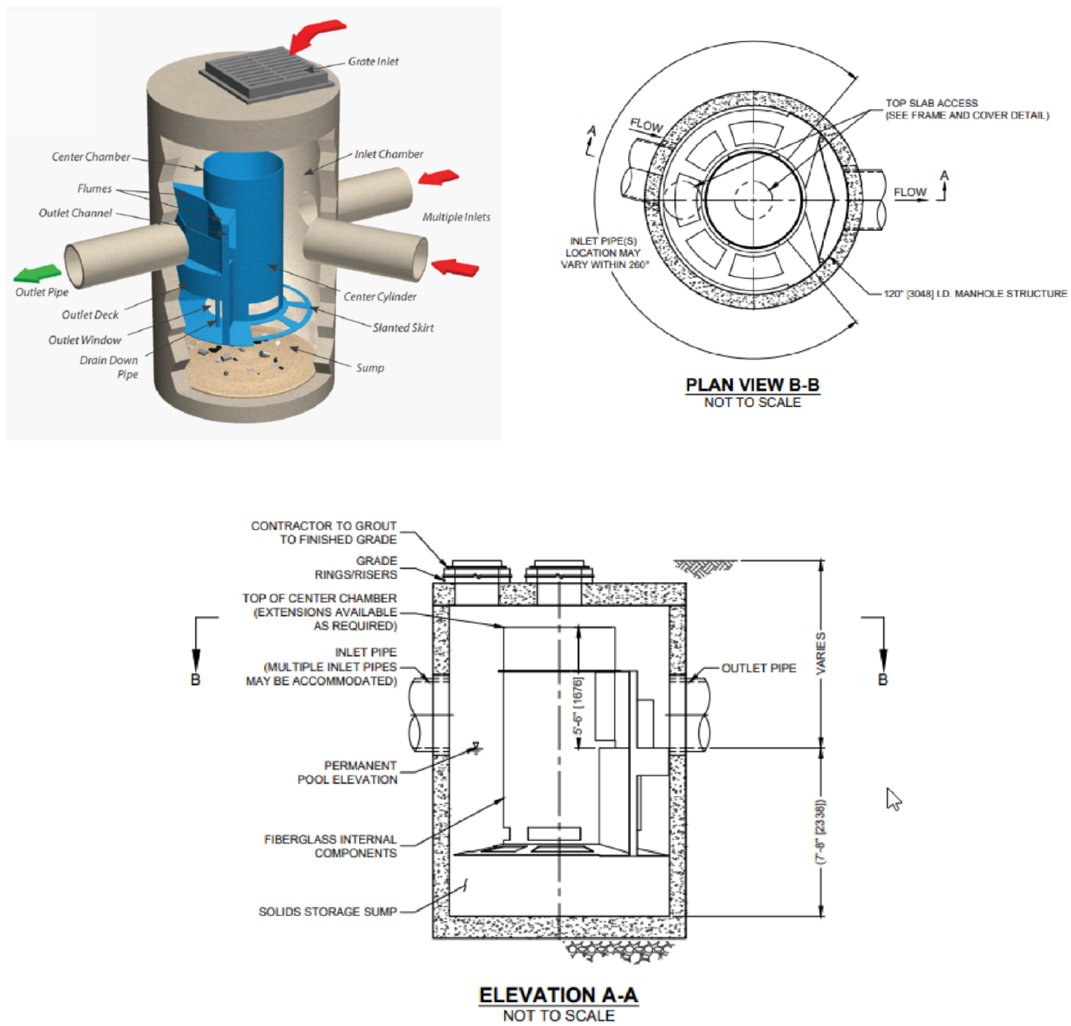


Figure 4-4. Proposed Stormwater BMP Placement
Baboosic Lake Drainage Study



Contech Cascade Hydrodynamic Separator, model CS-10, shown here as a sample. Other models and manufacturers of hydrodynamic separators are available.

Figure 4-5. Hydrodynamic Separator Typical Diagram

Baboosic Lake Drainage Study

AECOM

DATE: 11/9/2022

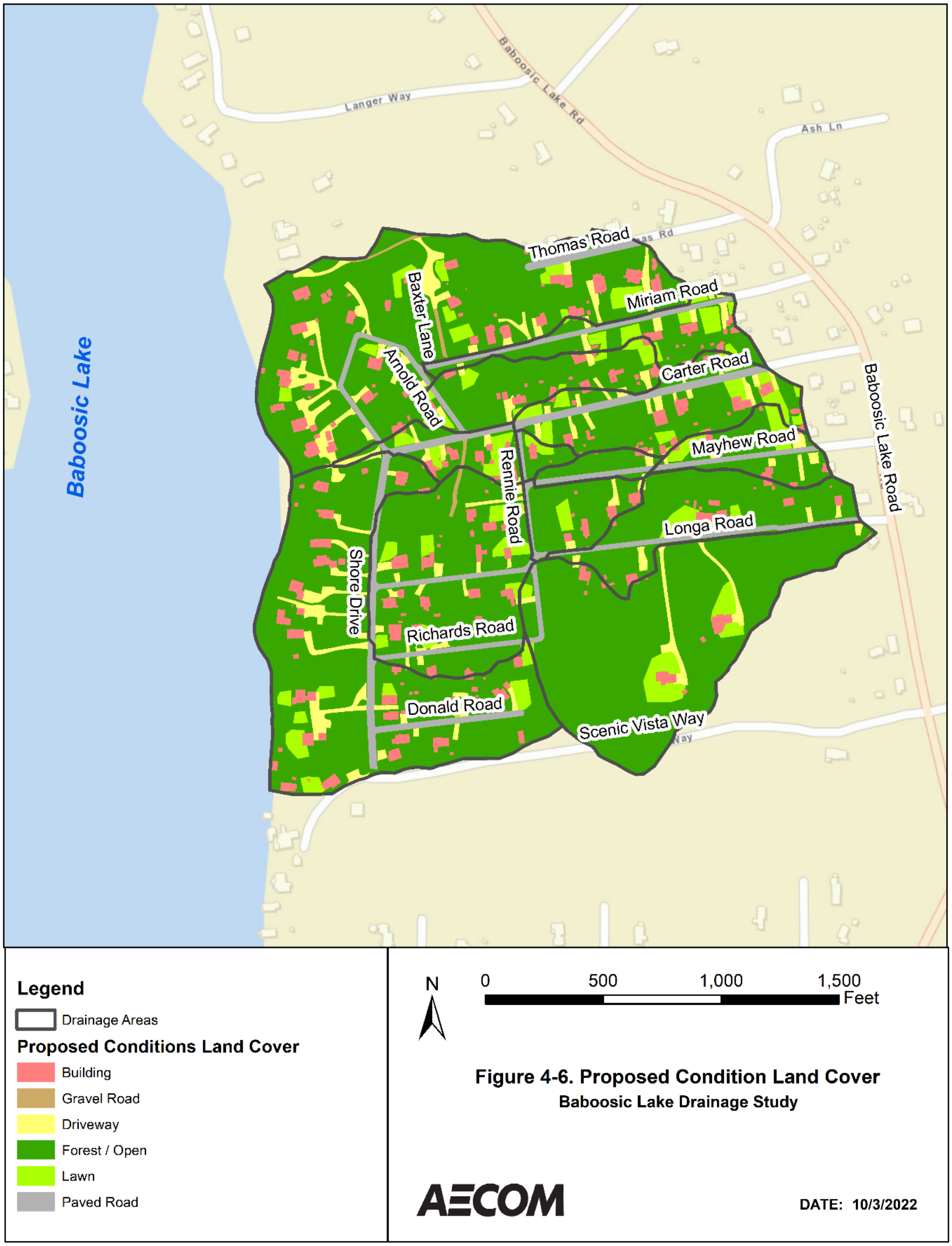


Figure 4-6. Proposed Condition Land Cover
Baboosic Lake Drainage Study

AECOM

DATE: 10/3/2022

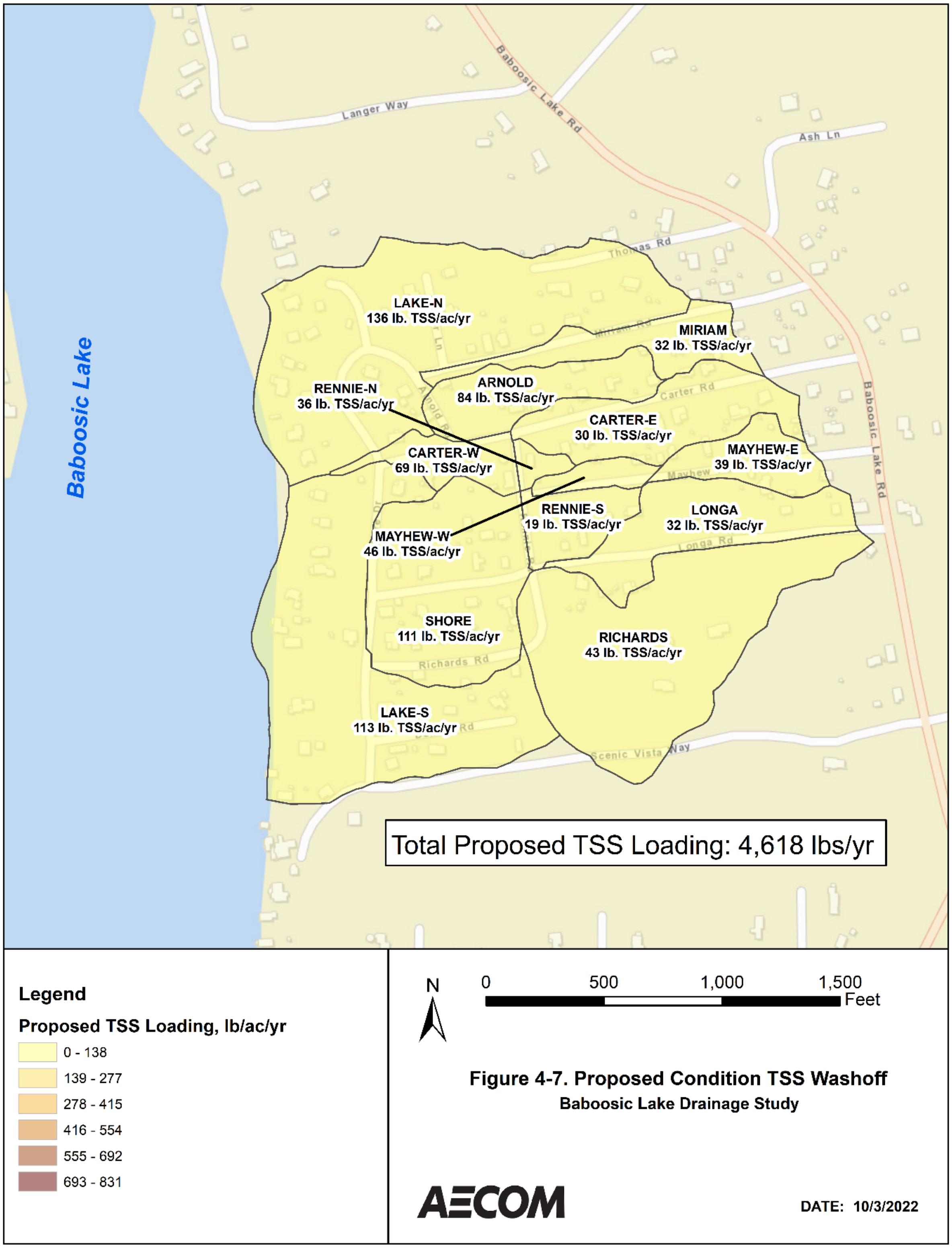


Figure 4-7. Proposed Condition TSS Washoff

Baboosic Lake Drainage Study

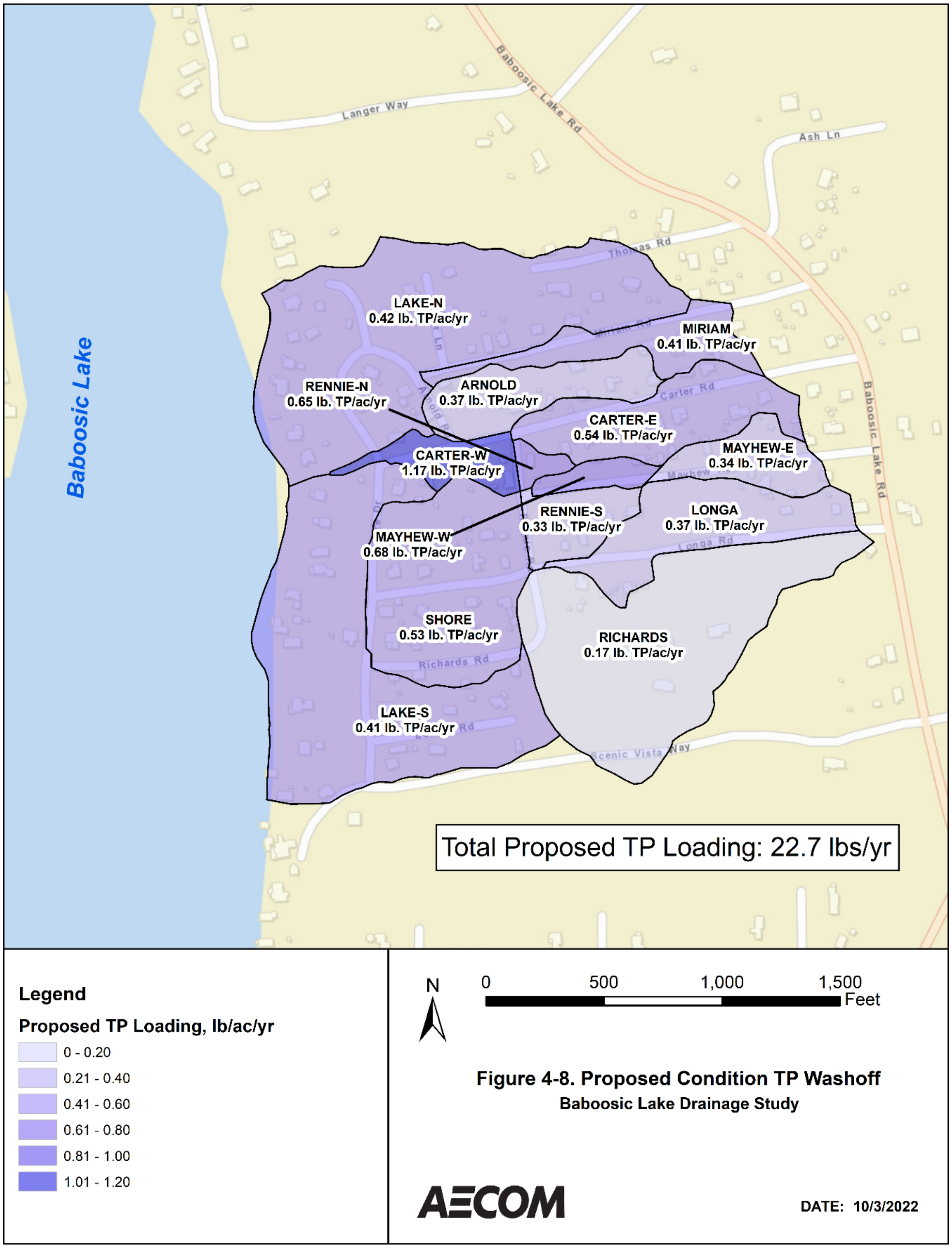


Figure 4-8. Proposed Condition TP Washoff
Baboosic Lake Drainage Study

AECOM

DATE: 10/3/2022

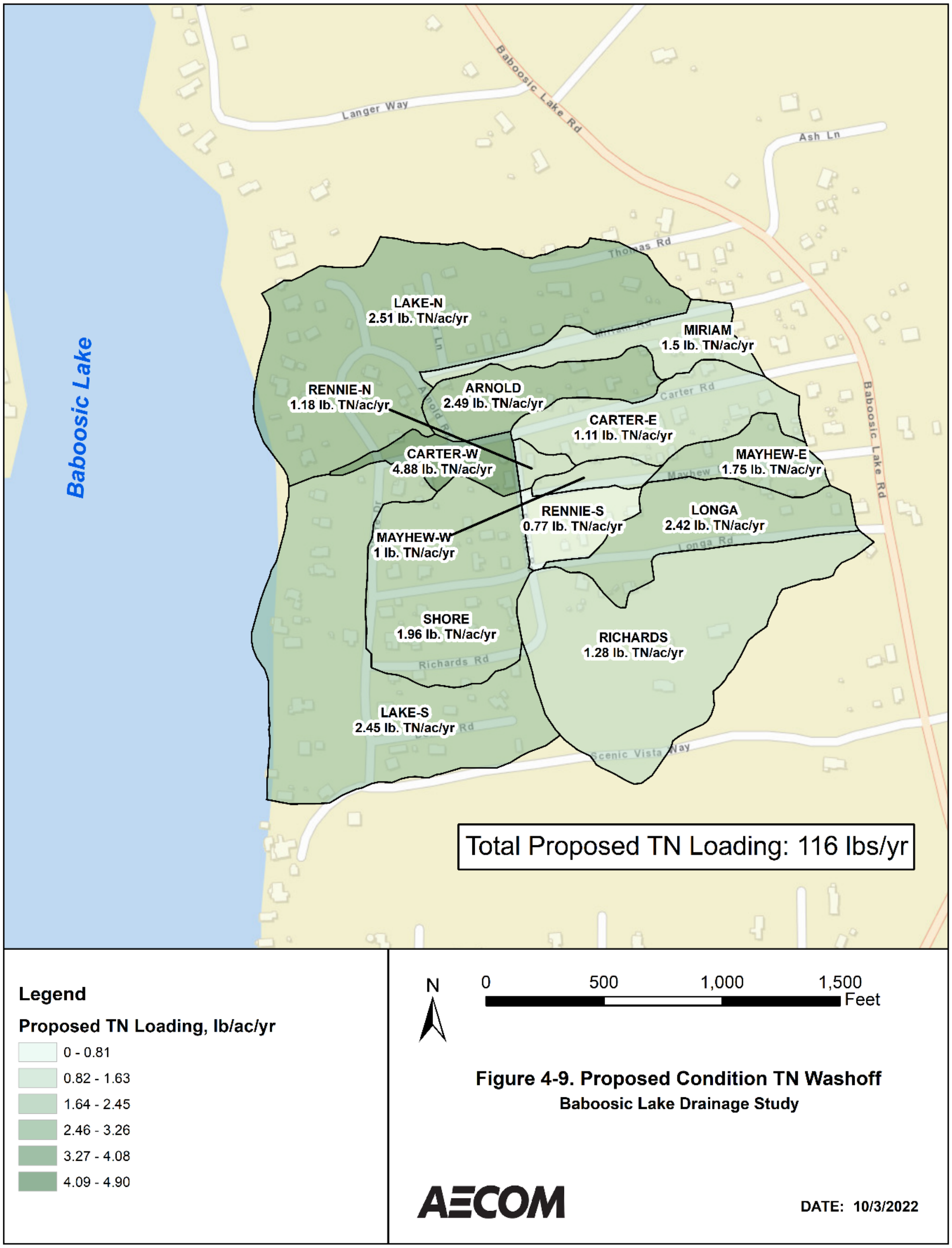


Figure 4-9. Proposed Condition TN Washoff

Baboosic Lake Drainage Study

Legend

- Outfalls
- Existing Stormwater Conduit
- Baboosic Lake (Direct)
- Carter Rd. Outfall
- Shore Dr. Outfall

N

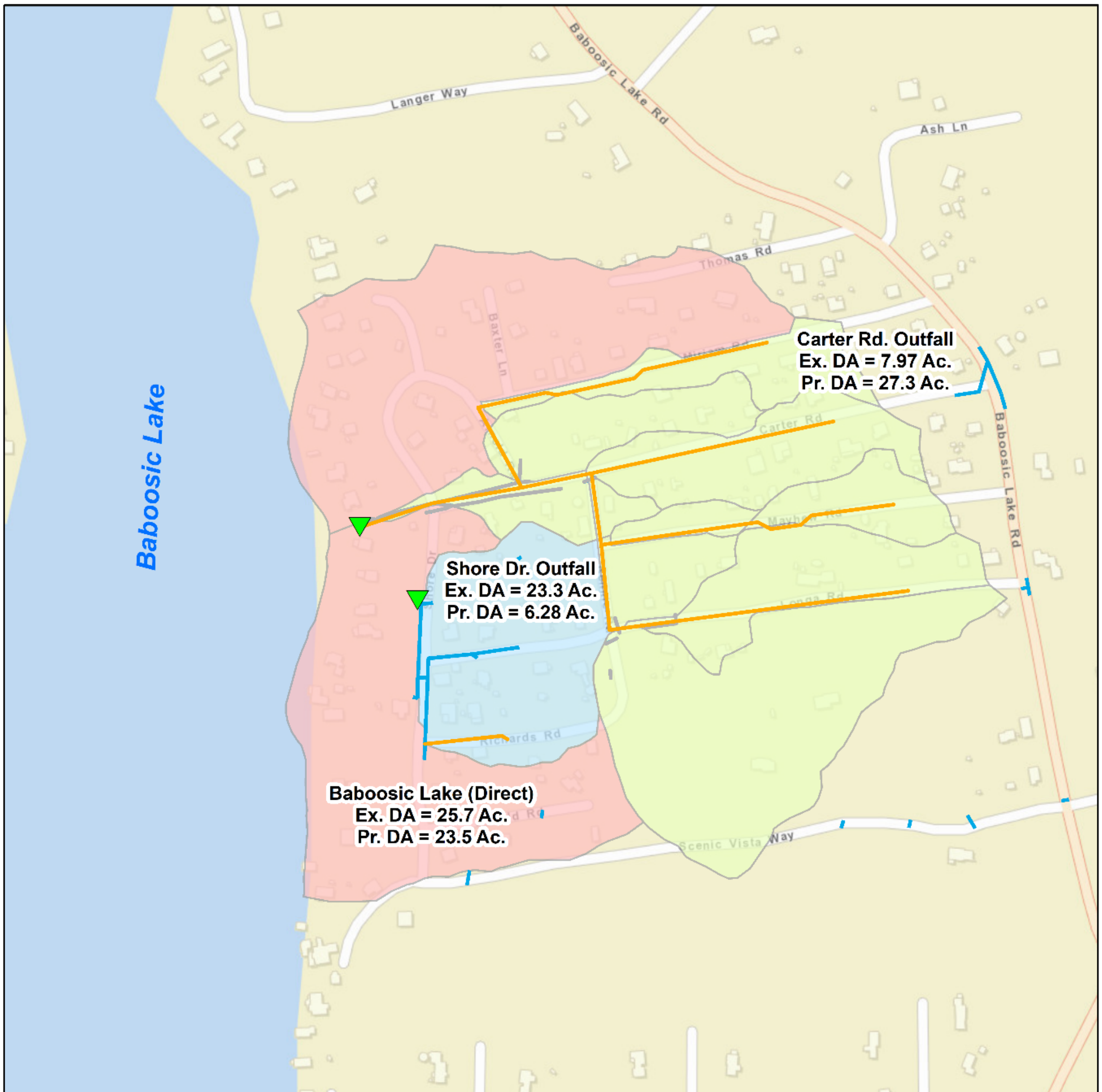
0 500 1,000 1,500 Feet

Figure 4-10. Existing Stormwater Outfalls and Contributing Drainage Areas

Baboosic Lake Drainage Study

AECOM

DATE: 10/3/2022



Legend

- Outfalls
- Proposed Drainage Conduit
- Existing Conduit to Remove/Modify
- Existing Drainage Conduit to Remain

Contributing Drainage Areas

- Baboosic Lake (Direct)
- Carter Rd. Outfall
- Shore Dr. Outfall

N

0 500 1,000 1,500 Feet

Figure 4-11. Proposed Drainage Network and Contributing Drainage Area

Baboosic Lake Drainage Study

AECOM

DATE: 10/3/2022

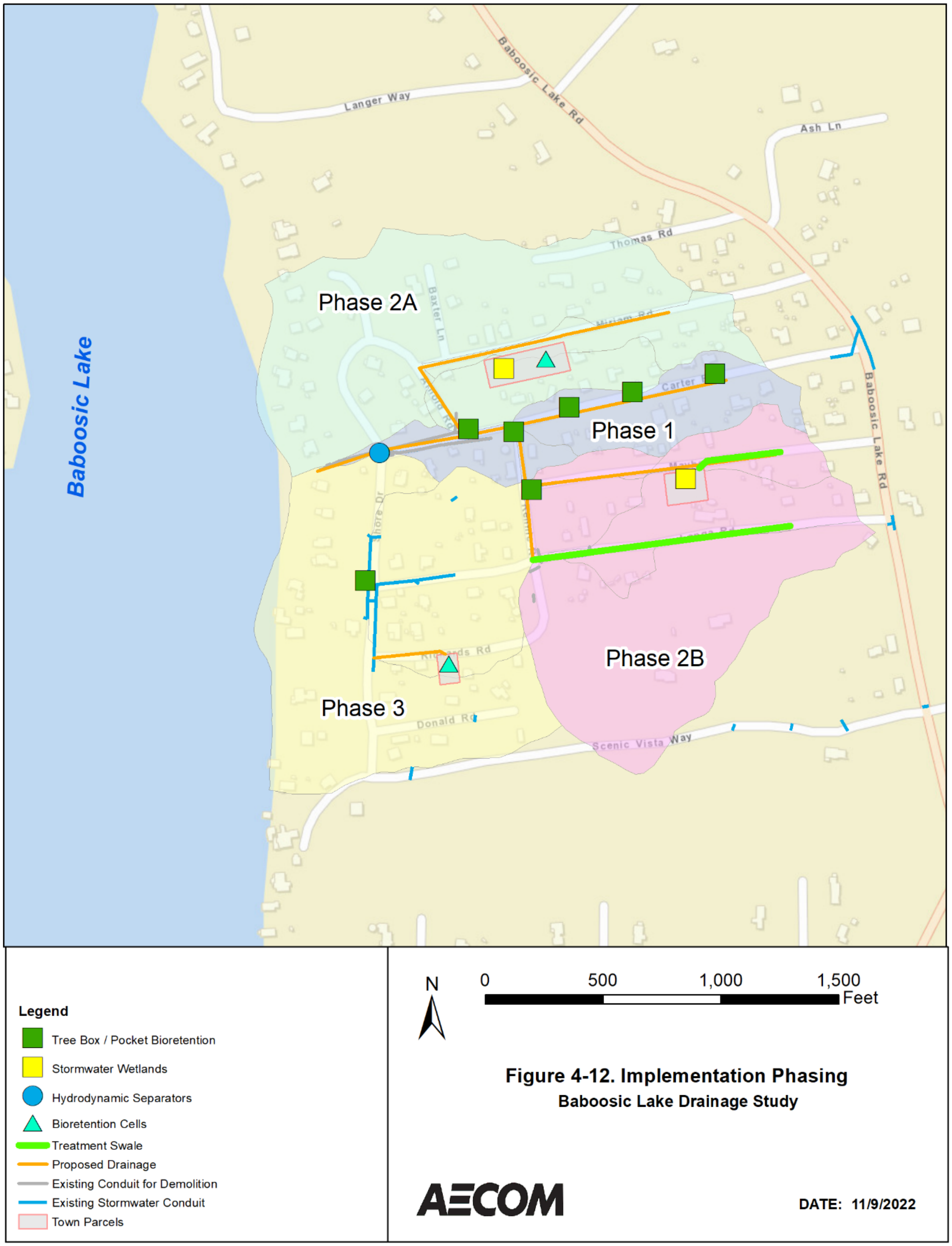


Figure 4-12. Implementation Phasing

Baboosic Lake Drainage Study

AECOM

DATE: 11/9/2022

Appendix A – CWSRF Meeting Records

Baboosic Lake (Pine Knoll Shores) Drainage Study Project

Town of Merrimack, New Hampshire

Kick Off Meeting

April 6, 2022

Sign-in Sheet

Name	Organization	Signature
Kyle Fox	Merrimack DPW	Kyle Fox
Kevin Anderson	Merrimack DPW	[illegible]
Deborah Loiselle	NHDES	Deborah Loiselle
Dennis Greene	NHDES	
Jeff Marcoux	NHDES	[illegible]
Yan Zhang	AECOM	Yan Zhang
Michaela Morrisey	AECOM	Michaela Morrisey

Baboosic Lake (Pine Knoll Shores) Drainage Study Project

Town of Merrimack, New Hampshire

Kick Off Meeting

Meeting Date:	1:00 PM EST, 04/06/2022
Meeting Location:	Merrimack, NH Town Hall, DPW Conference Room Teams Meeting Option
Project Name:	Merrimack Baboosic Lake Pine Knoll Shores Drainage Study
Project Number:	60680349
Subject:	Project Kickoff Meeting

☒ Meeting ☐ Telephone ☐ Conference Call

1.0 Safety Minutes (Michaela)

2.0 Introductions and Project Overview

a) Introduction of Project Staff:

- Merrimack DPW: Kyle Fox, Kevin Anderson
- NHDES: Deborah Losielle, Dennis Greene, Jeff Marcoux
- AECOM: Yan Zhang, Michaela Morrisey

3.0 CWSRF Requirements (NHDES)

4.0 Project Scope of Work

Task 1: Characterizing Existing Conditions

- Desktop Data Collection and Review
- Field Visit
- Base Plan Survey (Hancock Associates)

Task 2: Evaluations

- Hydrologic and Hydraulic, Water Quality Analysis
- Stormwater Collection and Treatment Concepts (Parcels, Roads)
- Abutter Impacts, BMP Evaluations

Task 3: Conceptual Design Plans and Engineering Study Report

Project Meetings

- Kickoff – 04/06
- Mid-Level Meeting/Design Concept Meeting #1
- Design Concept Meeting #2
- Wrap-up Meeting/Stake Holder Meeting

5.0 Project Schedule and Deliverables

a) Proposed Project Schedule – April 6th for approximately 4 months.

		April				May					June				July				August				
	Task Items	4/4	4/11	4/18	4/25	5/2	5/9	5/16	5/23	5/30	6/6	6/13	6/20	6/27	7/4	7/11	7/18	7/25	8/1	8/8	8/15	8/22	8/29
1	Desktop Data Review and Field Visit																						
2	Base Plan Survey																						
3	H&H, Water Quality Analysis																						
4	Stormwater Collection/Treatment, Roadway Rehabilitation Improvement Concept Development																						
5	BMP Ranking, Abutter Impacts																						
6	Conceptual Design Plan and Engineering Report (Draft & Final)																						
7	Meetings	Kickoff									Mid-Level			Design #2						Wrap up			

b) Deliverables:

- Conceptual Design Plans (up to 30%) (Draft mid-July)
- Engineering Study Report (Draft mid-July)

6.0 Quality Control

a) Merrimack DPW and NHDES Reviews

b) AECOM QMS (discipline reviews and check)

Baboosic Lake (Pine Knoll Shores) Drainage Study Project

Town of Merrimack, New Hampshire

Kick Off Meeting Notes

Meeting Date:	1:00 - 3 PM EST, 04/06/2022
Meeting Location:	Merrimack, NH Town Hall, DPW Conference Room
	Teams Meeting Option
Project Name:	Merrimack Baboosic Lake Pine Knoll Shores Drainage Study
Project Number:	60680349
Subject:	Project Kickoff Meeting

☒ Meeting ☐ Telephone ☐ Conference Call

Attendees:

Merrimack DPW: Kyle Fox, Kevin Anderson

NHDES: Deborah Loiselle, Jeff Marcoux

AECOM: Yan Zhang, Michaela Morrisey

1.0 Safety Minutes

- Michaela Morrisey presented a safety minute on preventing tick bites.

2.0 Introductions and Project Overview

- Yan presented AECOM team organization, roles, and responsibilities.
- Primary contact at Town of Merrimack: Kevin Anderson. Responsible for site access, traffic control, opening drainage structures, addressing neighborhood concerns, and researching town records.
- Primary contact at NHDES: Deborah Loiselle. Deborah can address questions associated with CWSRF Requirements and connect the project team with other NHDES personnel, if needed.
- Jeff Marcoux helped to develop the 2014 Water Management Plan for Baboosic Lake. Jeff mentioned that he can share the 2014 model with AECOM. He mentioned that UNH monitors the Lake for phosphorus and should have current data.
- Dennis Greene was unable to attend the meeting. Dennis is involved with the Wastewater Bureau and Clean Water SRF. He will be more involved with the project in the construction phase.
- AECOM's project communication with Merrimack will be addressed to both Mr. Kyle Fox and Kevin Anderson.

3.0 CWSRF Requirements

- Deborah discussed the requirements of the CWSRF, including the three required meetings. She expressed that she would like to attend all project meetings (4 are planned) and will use one of the mid-level meetings to satisfy the CWSRF second meeting requirement.
- The project deliverables (draft and final) will be shared both with the Town of Merrimack and NHDES. NHDES prefers electronic copies of the documents.

- Deborah discussed the deadlines associated with the grant. The current completion date is set for 1/2/2023, with the next deadline 10 months later. Extensions are possible with reasonable notice being given to Deborah.

4.0 <u>Review of Project Scope of Work</u>

- Yan presented slides on the scope of work and potential BMP solutions.
- The team reviewed the 2001 survey (Meridian) and site figures that identify town-owned parcels that can be used for stormwater BMPs.
- The Town of Merrimack shared that open and closed drainage solutions are acceptable under the Town Zoning Laws. They also mentioned that the Town would like to pave all of the roads in the subdivision. A one-way road would be 16-feet (or 12+2+2 feet) wide and a 2-way road would be 20-24 feet in width. However, the town may be flexible with road widths due to site constraints and low traffic count in the subdivision.
- The Town of Merrimack shared that there are some existing leeching catch basins in Merrimack and they are not very effective. They have issues with clogging and may not have a long useful life. Kevin added that Fish & Wildlife sometimes adds additional requirements to deep sump catch basins (adding screens) to prevent turtles and other animals from becoming trapped within the device. The team agreed that impacts to the environment and wildlife may be a factor to consider in the BMP matrix.
- The Town of Merrimack is most interested in lower maintenance BMPs (due to the small DPW staff) and BMPs with a long service life.
- Deborah shared information about the NHDES Soak up the Rain Program, run by Lisa Loosigian. The program helps homeowners install ecofriendly BMPs, like rain gardens, on their properties. Lisa may be able to recommend BMPs for the subdivision.
- Deborah mentioned that some existing data may be available through Shoreline permits. The NH One Stop tool can be used to see if there are any recent permits in the subdivision.
- Deborah shared information on a funding opportunity for the Town to implement the drainage improvement projects in the subdivision under the Clean Water SRF program. The preapplication deadline is June 1st.

5.0 <u>Project Schedule and Deliverables</u>

- The project team concurs with the proposed 4-month schedule, aiming to complete near end of August 2022. This schedule fits in with the CWSRF grant schedule, the Town's timeline to prepare for next year's CIP budget, and other external grant applications.
- Yan proposed the mid-level meeting (Meeting #2) to have the 10% design, and Meeting #3 to have the draft report. Exactly meeting times will be determined later. NHDES requires 2 weeks advance notice.
- The Town of Merrimack will decide if all meetings will be held in DPW Conference Room or in a more public setting.

6.0 <u>Quality Control</u>

- All deliverables are subject to AECOM's internal QC procedures before going out.
- Project deliverables will be sent to Merrimack DPW and NHDES for review.

7.0 <u>Data Requests and Action Items</u>

- AECOM provided Kyle and Kevin with a list of town data that is needed for the project, including septic system information and geotechnical data.
- AECOM Engineering team site visit (4/13) to collect data and define survey scope. Kevin Anderson will attend to assist team. Hancock Surveyor may participate the site visit.

- Town to provide road pavement and traffic layout plan so AECOM can start working on drainage infrastructure evaluation in the subdivision and water quality modeling to determine “hotspots”.
- Modeling to determine “hot spots” of phosphorus within subdivision (AECOM).
- Kevin emailed the CAD file of the 2001 Meridian Survey to the AECOM team following the meeting.
- Kyle will facilitate with Jeff to obtain model used in the 2014 Watershed Management Plan and the phosphorus testing data from UNH.

Baboosic Lake (Pine Knoll Shores) Drainage Study Project

Town of Merrimack, New Hampshire

Mid-Level Meeting

July 14, 2022

Sign-in Sheet

Name	Organization	Signature
Kyle Fox	Merrimack DPW	
Deborah Loiselle	NHDES	
N.S. Dennis Greene	NHDES	
Jeff Marcoux	NHDES	
Yan Zhang	AECOM	
Craig Drennan	AECOM	
Tim Belanger	Merrimack DPW	
Emma Liptrap	Merrimack DPW	
Alex Giuffrida	Merrimack DPW	

Baboosic Lake (Pine Knoll Shores) Drainage Study Project
Town of Merrimack, New Hampshire

Mid-Level Meeting

Meeting Date:	1:30 PM EST, 07/14/2022
Meeting Location:	Concord, NHDES Conference Room #313
	Teams Meeting Option
Project Name:	Merrimack Baboosic Lake Pine Knoll Shores Drainage Study
Project Number:	60680349
Subject:	Mid-Level Meeting: Design Concept

☒ Meeting ☐ Telephone ☐ Conference Call

1.0 <u>Safety Minutes</u> (Craig)

2.0 <u>Meeting Attendees</u>

- Merrimack DPW: Kyle Fox
- NHDES: Deborah Losielle, Dennis Greene, Jeff Marcoux
- AECOM: Yan Zhang, Craig Drennan

3.0 <u>Project Update</u>

Task 1: Characterizing Existing Conditions

- Field Visit and Data Collection
- Base Plan Survey (Hancock Associates)

Task 2: Existing Condition Evaluations

- Pollutant wash-off model, methodology and Key parameters
- Pollutant loading analysis results and comparison to TMDL
- Proposed BMP siting
- Abutter impact analysis approach
- BMP selection criteria
- Past planning implementation grant opportunities

4.0 <u>Project Schedule Update</u>

a) Project Schedule Update – Delayed by approximately 6 weeks due to survey.

		April				May					June				July				August					September			
	Task Items	4/4	4/11	4/18	4/25	5/2	5/9	5/16	5/23	5/30	6/6	6/13	6/20	6/27	7/4	7/11	7/18	7/25	8/1	8/8	8/15	8/22	8/29	9/5	9/12	9/19	9/26
1	Desktop Data Review and Field Visit																										
2	Base Plan Survey													Draft													
3	H&H, Water Quality Analysis																										
4	Stormwater Collection/Treatment, Roadway Rehabilitation Improvement Concept Development																										
5	BMP Ranking, Abutter Impacts																										
6	Conceptual Design Plan and Engineering Report (Draft & Final)																										
7	Meetings	Kickoff														Mid-Level					Design #2				Wrap up		

<u>Project Meetings</u>

- *Kickoff – 04/06*
- Mid-Level meeting/design concept Meeting #1 – 07/14
- Design concept meeting #2 (mid to late August)
- Wrap-up meeting/stake holder meeting (mid to late September)

b) Deliverables:

- Conceptual Design Plans (up to 30%) (Draft late-August)
- Engineering Study Report (Draft late-August)

Baboosic Lake (Pine Knoll Shores) Drainage Study Project

Town of Merrimack, New Hampshire

Mid-Level Meeting Notes

Meeting Date:	1:30 – 3:30 PM EST, 07/14/2022
Meeting Location:	Concord, NHDES Conference Room No. 313
Project Name:	Merrimack Baboosic Lake Pine Knoll Shores Drainage Study
Project Number:	60680349
Subject:	Mid-Level Meeting: Design Concept Discussion

☒ Meeting ☐ Telephone ☐ Conference Call

Attendees:

Merrimack DPW: Kyle Fox, Tim Belanger, Emma Liptrap, Alex Griffida

NHDES: Deborah Loiselle, Jeff Marcoux

AECOM: Yan Zhang, Craig Drennan

1.0 Safety Minutes

- Craig Drennan presented a safety minute on fertilizer & insecticide use & hazards.

2.0 Project Update: Task 1 (Characterizing Existing Conditions)

- Yan reviewed the project approach discussed in the kickoff meeting.
- Data collection efforts conducted to date: have included site visit (AECOM, DPW, Hancock Associates); base plan survey (Hancock Associates); geospatial & geotechnical data collection (AECOM & DPW)
- Field visit was useful to locate/verify drainage structures, assess road conditions, inspect town-owned lots.
- Survey substantially completed, awaiting final deliverable from Hancock. DPW indicated that they would like to be provided with final survey deliverable.
- Town has furnished AECOM with geotechnical & test pit data from septic system development across subdivision: will be useful in siting various BMP types along roadways and in town land.
- Geospatial data from Town has included parcels, driveways, road extents, building footprints from GIS database.

3.0 Project Update: Task 2 (Existing Condition Evaluations)

- Base plan survey was used to delineate the subdivision into drainage basins with greater details, which were further divided based on roadways that may be paved (which would substantially change drainage pattern in these areas).
- Land use coverage of the subdivision was developed from town and survey datasets. Land use classes were chosen in reference to NHDES washoff model. NHDES indicated that a recent MS4

hotspot report may be useful to consider as the land use & washoff model is described in the final report.

- AECOM has developed a pollutant washoff loading model using the Simple Model framework published by NHDES. NHDES model has been amended to include gravel roads as a land use type.
- Washoff model produces annualized loadings of TSS, TN, TP under exiting condition. The TP predictions compared in general agreement with the scaled TP load in Baboosic TMDL.
- AECOM presented the pollutant loading map for TSS and TP by drainage basins. The relative pollutant loading density can be directly attributed to land use such as gravel/dirt roads, home lawns, which contribute the most sediments and nutrients from home fertilizer use. NHDES indicated that a similar map for TN would be worthwhile to show.

4.0 <u>Next steps: BMP Siting</u>

- AECOM presented slides demonstrating preliminary BMP sting along roadways & in Town-owned parcels.
- Town indicated that roadways could be narrowed to fit BMPs that require more easement width: Town council has been supporting making some of these roads one-way. Could a sight-distance analysis be conducted to determine which roads would be best suited for one-way traffic?
- AECOM noted that Baxter Lane is not included in the current BMP siting plan. Town indicated that Baxter is a private road, so this is not an issue.
- Two drainage alternatives were presented. One in which the Shore Drive outfall is extended to the lake; one in which it is not. Town indicated that extending the outfall to the lake through the private ROW would be nearly impossible, as it would require the sign-off of every homeowner in the subdivision. More likely is installing the line through the private property of the homeowner at 20 Shore Drive. This would require discussion with the homeowner. Such improvement will help alleviate flooding which has been complained by the homeowner.
- Town is considering buying a second vacuum excavator truck for catch basin maintenance- so hydrodynamic separators and deep sump basins should be kept on the table as potential treatment methods.

5.0 <u>Next steps: Funding & Grant Opportunities</u>

- NHDES proposed two primary funding methodologies to implement or to continue the stormwater work proposed by this project: EPA Section 319 grants and another CWSRF loan.
- Section 319 grants cannot be used to pay for anything required by the state MS4 permit- but anything that goes above and beyond these requirements qualifies. Primarily, implementations that reduce runoff volume are ideal candidates. Jeff Marcoux is the best person to assist and advise on 319 grant applications.
- In addition, a second round of CWSRF funding may be applied for. NHDES indicated that the CWSRF program may transition to a grant from a loan (which is harder for municipalities to acquire), but the timeline is unclear for this to happen.
- Two types of CWSRF loans are available: planning and infrastructure. Planning CWSRF loans covered up to 100K of principal forgiveness for planning work that covered up to 30% design. Infrastructure loans are very low interest loans with 15-30% principal forgiveness that cover design & execution of projects at a greater-than-30% design level. Combination of planning plus infrastructure loans are also available as an option.
- Would be useful to add columns to the final BMP matrix deliverable indicating eligibility of each BMP for coverage under each funding source.
- For upland BMPs being considered on town land: may be feasible for these to be implemented early (in the next year) under a Section 319 grant. This would pull some monetary pressure off the eventual implementation of the Pine Knoll Shores project.

6.0 <u>Project Schedule and Deliverables</u>

- AECOM noted that the project is behind the initial schedule by 5-6 weeks due to delays in the survey deliverable. NHDES and Town noted that project is still well within the schedule of CWSRF grant requirements and the Town's planning timeline for next year's spending plan.
- Preliminary dates for Mid-Level Meeting #2 were chosen- potentially Thursday, August 23rd to be held at Merrimack DPW. Meeting will cover final BMP matrix, layout, BMP designs, detailed abutter impact evaluation. It is later agreed that stakeholders should be engaged at this meeting so to finalize the design concepts with input of all parties.
- It was discussed Final wrap-up meeting, required by grant, to be held at Town Council meeting on September 22 at 7pm. Project will be presented as a line-item on the council agenda, and will be used to get stakeholder feedback on planning project. NHDES pointed out that a final project report will be needed to wrap up the project per grant requirement.

7.0 <u>Data Requests and Action Items</u>

- AECOM will provide Town final survey deliverables once provided by Hancock & Associates.
- AECOM Engineering team will review available rights-of-way, presence of ditches, and likelihood of tree removal to determine / prioritize certain BMPs in certain applications. Roadway widths under one- and two-way conditions will also be assessed. Craig will reach out to Kyle once a preliminary assessment has been conducted to this effect.
- AECOM will continue work on proposed conditions washoff pollutant loading analysis, BMP siting and ROW analysis, and BMP ranking matrix. AECOM will also begin work on the final engineering report to be delivered upon completion of CWSRF project.

Baboosic Lake (Pine Knoll Shores) Drainage Study Project

Town of Merrimack, New Hampshire

Design Concept Meeting #2

August 23, 2022

Sign-in Sheet

Name	Organization	Signature
Kyle Fox	Merrimack DPW	Kyle Fox
Ashley Litwinenko	Merrimack DPW	Ashley M Litwinenko
Deborah Loiselle	NHDES	Deb Loiselle
Dennis Greene	NHDES	
Jeff Marcoux	NHDES	[signature]
Yan Zhang	AECOM	Yan Zhang
Craig Drennan	AECOM	[signature]
David Carbonneau	AECOM	[signature]
DAWN TUOMALA	MERRIMACK DPW	D Tuomala

Baboosic Lake (Pine Knoll Shores) Drainage Study Project

Town of Merrimack, New Hampshire

Mid-Level Meeting

Meeting Date:	1:30 PM EST, 08/23/2022
Meeting Location:	Communication Development Meeting Room, Merrimack Town Hall
	Teams Meeting Option
Project Name:	Merrimack Baboosic Lake Pine Knoll Shores Drainage Study
Project Number:	60680349
Subject:	Design Concept Meeting #2

☒ Meeting ☐ Telephone ☐ Conference Call

1.0 Safety Minutes (David)

2.0 Meeting Attendees

- Merrimack DPW: Kyle Fox, Ashley Litwinenko
- NHDES: Deborah Losielle, Dennis Greene, Jeff Marcoux
- AECOM: Yan Zhang, Craig Drennan, David Carbonneau

3.0 Project Update

Task 1: Characterizing Existing Conditions – Completed.

Task 2: Existing Condition Evaluations – Completed.

Task 3: Engineering Study and Conceptual Design

Overview of approach to selecting & siting BMPs
Review of selected “Projects” for consideration
Project ranking & summary matrix
Proposed condition washoff modeling
Next steps

4.0 Project Schedule Update

a) Project Schedule Update – Delayed by approximately 6 weeks due to survey. **Extending time period for final deliverable to incorporate feedback from final meeting into report.**

		April				May					June				July				August					September				October			
	Task Items	4/4	4/11	4/18	4/25	5/2	5/9	5/16	5/23	5/30	6/6	6/13	6/20	6/27	7/4	7/11	7/18	7/25	8/1	8/8	8/15	8/22	8/29	9/5	9/12	9/19	9/26	10/3	10/10	10/17	10/24
1	Desktop Data Review and Field Visit																														
2	Base Plan Survey													Draft																	
3	H&H, Water Quality Analysis																														
4	Stormwater Collection/Treatment, Roadway Rehabilitation Improvement Concept Development																														
5	BMP Ranking, Abutter Impacts																														
6	Conceptual Design Plan and Engineering Report (Draft & Final)																														
7	Meetings	Kickoff														Mid-Level						Design #2					Wrap up				

Project Meetings

- *Kickoff – 04/06*
- Mid-Level meeting/design concept Meeting #1 – 07/14
- Design concept meeting #2 – 08/23
- Wrap-up meeting/stake holder meeting (09/22?)

b) Deliverables:

- Conceptual Design Plans (up to 30%) (Draft mid-September)
- Engineering Study Report (Draft mid-September)

Baboosic Lake (Pine Knoll Shores) Drainage Study Project

Town of Merrimack, New Hampshire

Design Concept Meeting #2 Notes

Meeting Date:	1:30 – 3:30 PM EST, 08/23/2022
Meeting Location:	Merrimack Town Hall, Community Development Meeting Room
Project Name:	Merrimack Baboosic Lake Pine Knoll Shores Drainage Study
Project Number:	60680349
Subject:	Design Concept Meeting, # 2

☒ Meeting ☐ Telephone ☐ Conference Call

Attendees:

Merrimack DPW: Kyle Fox, Ashley Litwinenko, Dawn Tuomala

NHDES: Deborah Loiselle, Jeff Marcoux

AECOM: Yan Zhang, Craig Drennan, David Carbonneau

1.0 Safety Minutes

- David presented a safety minute on home renovations & hazard awareness.

2.0 Review from Last Meeting: Existing Conditions & Design Approach

- Yan reviewed the contents of the last project meeting, including the existing conditions of roadway and drainage infrastructure within the subdivision.
- AECOM reviewed the existing condition pollutant loading for TSS, TN, and TP. AECOM pointed out that understanding the source of the pollutants provides the basis to BMP development and placement.
- Yan walked through the conceptual approach taken to formulate stormwater design concepts in the subdivision targeted to address the pollutant loading hotspots. Implementations considered following three main steps:
    1. Pave and repave the roadways
    2. Drain the newly paved roads
    3. Treat the stormwater running off from the subdivision to further reduce pollutant loading to the lake.
- Proposed projects will be evaluated based on treatment performance, ROW limitation, abutter impact, cost and maintenance, grant eligibility, etc. AECOM emphasized that BMPs will be sized within the Town's ROW and properties to the maximum extent practicable.

3.0 Proposed Projects / Implementations

- AECOM proposed six projects in the subdivision and reviewed each of these in terms of project location, concept, cost (where available), and pollutant reductions.

- The proposed projects include full roadway paving & drainage; localized BMPs (including 7 Tree Box Filters and 1 Hydrodynamic Separator); and three regional BMPs utilizing town-owned property in the subdivision. The regional BMPs include a bioretention cell on Richards Road, a stormwater wetland on Mayhew Road, and an educational / exhibition stormwater park on Miriam Road that would demonstrate both bioretention and stormwater wetlands.
- Kyle Fox stated concerns regarding maintenance requirements for the Tree Box Filters. The Town owns vac trucks and would have no issue maintaining the hydrodynamic separators as they currently do catch basins, but what would be involved with maintaining the tree boxes? Could landscapers or contractors be hired to do this maintenance instead of Town staff? In addition, Kyle requested that the final cost-out of each project include an estimated annual O&M cost.
- NHDES staff indicated that the stormwater park would be eligible for credits towards the MS4 permit.
- Town asked whether subsurface infiltration systems had been considered for implementation on town parcels. Craig indicated that they had not because underground systems are typically used in space-limited areas and they involve more extensive O&M. On-the-surface systems are easier to implement and friendlier in terms of cost and O&M.
- AECOM presented a preliminary summary matrix comparing the 6 projects. Town noted that the list should be ordered in terms of order of implementation such as phasing.
- Jeff Marcoux noted that all projects would be potentially eligible for Section 319 grants.
- Town specifically liked the regional BMP installations as good candidates for external funding. Town suggested that AECOM re-group the projects based on location within the subdivision. For instance, the Miriam stormwater park "project" could include paving Carter and Miriam roads; upgrading the existing drainage network; installing new drainage, and building the park, rather than having roadway paving and drainage be its own separate implementation. Then, washoff reductions can be reported for each regional project.
- NHDES listed several other grant programs that the Town could pursue; including the Mooseplate Grant and the New Hampshire Charitable Foundation.
- Town indicated that these projects would be relatively challenging in the eyes of the Town Council due to cost and to the fact that the projects only benefit small groups of residents. But the projects would receive buy-in from the subdivision residents with relative ease.
- AECOM presented the modeled pollutant reductions with the proposed BMPs. Jeff Marcoux confirmed that the modeled pollutant reduction rates are plausible.
- Deborah asked how the NHDES SIMPLE washoff model compares to the washoff model outlined in Appendix F of the State MS4 permit? AECOM will research the MS4 permit washoff model and provide update. AECOM will document the washoff modeling comparison in the final engineering report.

4.0 <u>Next steps: Hydraulic Modeling; Public Meeting; Draft Deliverables, Action Items</u>

- AECOM will be developing a hydraulic model to verify the capacity of the existing drain network & size the proposed network. Town requested model to be developed using HydroCAD (rather than PCSWMM; as initially scoped). NHDES will assist AECOM in filing a scope change request because the contract specifically stated PCSWMM would be used. Because both models are technically similar, NHDES expects that the request be approved.
- The project wrap-up meeting will be tentatively help in front of Town Council; likely to be 45 minutes to an hour-long presentation. While the initial goal was to target the council meeting on 9/22; all members agreed to reschedule to the 10/27 meeting.
- AECOM will aim to have a draft report & plans ready for review around 9/22, allowing time for Town & State feedback ahead of Council meeting.
- AECOM may schedule one interim Teams meeting to facility draft report review prior to the project wrap-up meeting. AECOM will aim to provide final deliverables to Town & State one to two weeks after the 10/27 meeting.
- AECOM will look into maintenance requirements & options for the tree box filters and circle back with Town on whether to keep tree boxes in future project plans. AECOM will also look at other potential alternatives for small-footprint nutrient removal, such as pocket bioretention cells, for comparison & alternate consideration.

- AECOM will finalize cost estimates for each project (once reconfigured), using NHDOT unit cost data and other information if necessary. O&M requirements will be included. The project cost estimate will incorporate project grouping/phasing consideration based on input from the Town.
- AECOM will update the project summary matrix with additional details on implementation and funding source eligibility, where applicable.

Appendix B – Site Visit Photolog

CITY/TOWN		PROJECT NO.	INSPECTION DATE
Merrimack, NH		**60680349**	**April 13, 2022**

PHOTOS

Photo 1. Silt-filled roadside swale along Carter Road. Swale accepts significant load from unpaved Rennie road.

Photo 2. Primary outfall to Baboosic Lake at end of Carter Road

CITY/TOWN		PROJECT NO.	INSPECTION DATE
Merrimack, NH		**60680349**	**April 13, 2022**

PHOTOS

Photo 3. Vegetation-dense town land on Richard Road.

Photo 4. Lowlands portion of town land along Miriam Road. Note the wetlands visible in the background.

CITY/TOWN		PROJECT NO.	INSPECTION DATE
Merrimack, NH		**60680349**	**April 13, 2022**

PHOTOS

Photo 5. Town property on Mayhew Road. Note the sediment washout onto the property from the adjacent road.

Photo 6. Overland flow draining from Shore Drive to Baboosic Lake through property at 20 Shore Drive.

CITY/TOWN		PROJECT NO.	INSPECTION DATE
Merrimack, NH		60680349	April 13, 2022

PHOTOS

Photo 7. Sediment washout area at corner of Mayhew & Rennie.

Photo 8. Former BMP Overflow catch basin at Carter & Arnold covered by 2” sediment (note: Carter is paved; Arnold is unpaved).

CITY/TOWN		PROJECT NO.	INSPECTION DATE
Merrimack, NH		**60680349**	**April 13, 2022**

PHOTOS

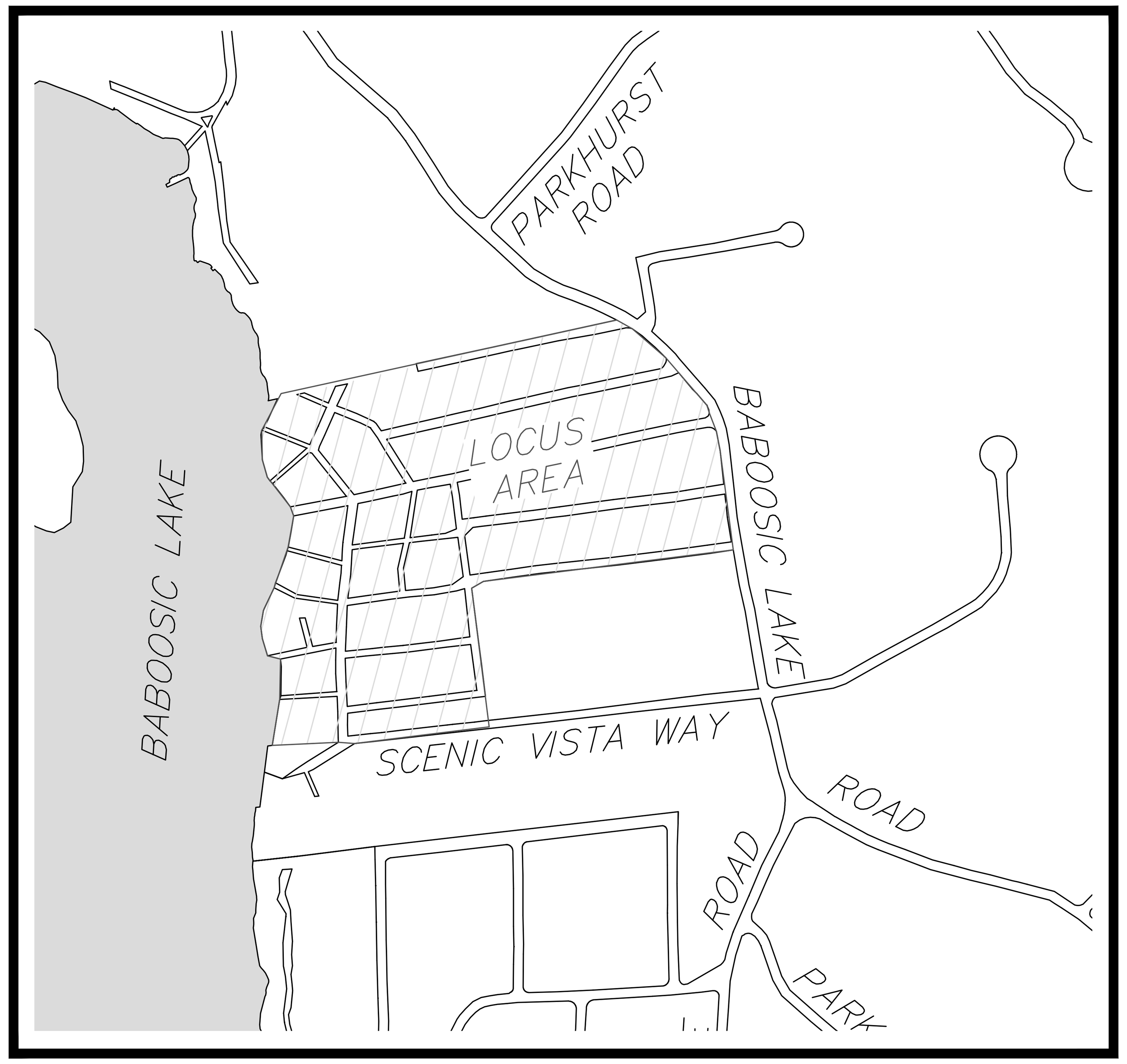
Photo 9. Silted-over catch basin at corner of Rennie & Carter (note: Carter is paved; Rennie is unpaved).

Photo 10. Roadway washout area on Baxter Lane. Note: crushed remnants of former 6” PVC culvert still visible in roadway where indicated. Residents removed half of piping; visible adjacent to roadway as indicated.

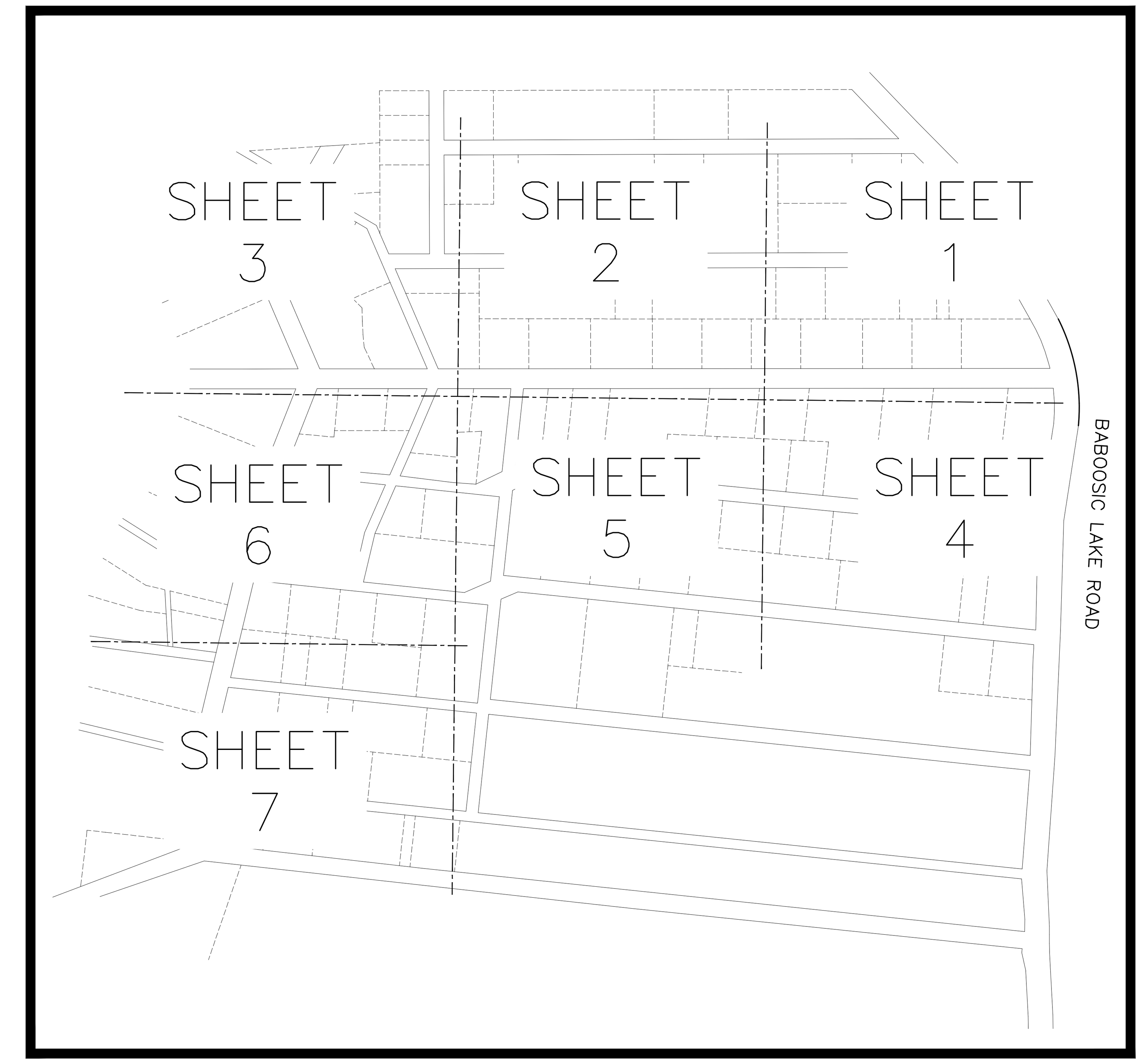
Appendix C – Conceptual Design Planset

TOWN OF MERRIMACK, NH
BABOOSIC LAKE - PINE KNOLL SHORES DRAINAGE STUDY

LOCUS MAP



KEY MAP



PREPARED FOR:
TOWN OF MERRIMACK
DEPT. OF PUBLIC WORKS
6 BABOOSIC LAKE ROAD
MERRIMACK, NH 03054

PREPARED BY:
AECOM
250 APOLLO DRIVE
CHELMSFORD, MA 01824

SEPTEMBER 2022

CONCEPTUAL DESIGN PACKAGE

NOT FOR PERMITTING OR CONSTRUCTION

NOTES:

1) THE VERTICAL DATUM FOR THIS SURVEY IS THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88). SAID DATUM WAS ESTABLISHED VIA GPS OBSERVATIONS UTILIZING NAD83 (NA2011) EPOCH 2010.00 (MYCS2) AND GEOID 18. ALL ELEVATIONS SHOWN IN US SURVEY FEET.

2) UNDERGROUND UTILITIES ARE SHOWN HEREON FROM FIELD LOCATIONS OF SURFACE VISIBLE STRUCTURES AND FROM "TOPOGRAPHIC SURVEY FOR PROPOSED WATER MAIN BABOOSIC LAKE ROAD" BY MERIDIAN LAND SERVICES, INC., DATED JUNE 19, 2001. UTILITY INFORMATION IS INCOMPLETE AND SHOULD BE VERIFIED FOR FUTURE DESIGN AND CONSTRUCTION WORK.

3) DRAINAGE INVERTS SHOWN WITH AN * WERE TAKEN FROM "TOPOGRAPHIC SURVEY FOR PROPOSED WATER MAIN BABOOSIC LAKE ROAD" BY MERIDIAN LAND SERVICES, INC., DATED JUNE 19, 2001 AND ADJUSTED TO CURRENT DATUM.

4) THIS PLAN IS THE RESULT OF AN ON-THE-GROUND INSTRUMENT SURVEY PERFORMED BY HANCOCK ASSOCIATES IN JUNE OF 2022.

5) A BOUNDARY SURVEY WAS NOT INCLUDED WITH THE SCOPE OF THIS SURVEY. BOUNDARY WAS TAKEN FROM MERRIMACK NEW HAMPSHIRE GIS.

6) WATER TABLE & INFILTRATION DATA ARE SHOWN HEREON ARE REFERENCED FROM TEST PIT RESULTS SHOWN IN SEPTIC SYSTEM PERMITTING RECORDS, PROVIDED TO AECOM BY THE TOWN OF MERRIMACK. LOCATIONS OF TEST PIT DATA SHOWN HERE ARE APPROXIMATED.

7) THE DESIGN CONCEPTS DEMONSTRATED HEREIN ARE A PRODUCT OF THE BABOOSIC LAKE (PINE KNOLL SHORES) DRAINAGE STUDY CONDUCTED BY AECOM IN SUMMER 2022. REFER TO REPORT FOR BASIS OF DESIGN AND ADDITIONAL INFORMATION.

CONTENTS:

LEGEND:

— 310 —	MAJOR TOPOGRAPHIC CONTOUR (5')	CCB	CAPE COD CURB
— 307 —	MINOR TOPOGRAPHIC CONTOUR (1')	CONC.	CONCRETE
	EDGE OF RIGHT-OF-WAY / PROPERTY LINE	CLF	CHAIN LINK FENCE
	PROPERTY LINE	RCP	REINFORCED CONCRETE PIPE
	EDGE OF GRAVEL ROAD (EX.)	INV	INVERT
	EDGE OF PAVED ROAD (EX.)	CMP	CORRUGATED METAL PIPE
	EDGE OF PAVED ROAD (PR.)	PVC	POLYVINYL CHLORIDE
— OH — OH —	OVERHEAD ELECTRIC	DMH	DRAIN MANHOLE (EX.)
— W — W — W —	WATER MAIN		DRAIN MANHOLE (PR.)
— D — D —	STORM DRAIN (EX.)		HYDRODYNAMIC SEPARATOR (PR.)
— PD — PD —	STORM DRAIN (PR.)	CB	CATCH BASIN (EX.)
	RIP-RAP (EX.)		CATCH BASIN (PR.)
	ROADSIDE DITCH (EX.)		TREE BOX FILTER (PR.)
	PROPOSED ASPHALT PAVING	SHWT	SEASONAL HIGH WATER TABLE
	PROPOSED CHANNEL STABILIZATION		EXISTING UTILITY POLE
	TOWN-OWNED PARCELS FOR DEVELOPMENT		WATER VALVE
	GRASS-LINED CONVEYANCE SWALE		HYDRANT
		6A-2/29	ASSESSORS MAP AND LOT
			TEST PIT LOCATION

AECOM

PROJECT
Baboosic Lake - Pine Knoll Shores Subdivision Drainage Study

CLIENT
Town of Merrimack
Department of Public Works
6 Baboosic Lake Road
Merrimack, NH 03054

CONSULTANT
AECOM
250 Apollo Drive
Chelmsford, MA 01824
978.905.2100 tel
www.aecom.com

DRAFT

ISSUE/REVISION

I/R	DATE	DESCRIPTION
B	11/09/2022	CONCEPT DESIGN
A	9/30/2022	ISSUE FOR REVIEW

PROJECT NUMBER
60680349

SHEET TITLE
COVER & NOTES

SHEET NUMBER
G-01

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AECOM

PROJECT

Baboosic Lake - Pine Knoll Shores Subdivision Drainage Study

CLIENT

Town of Merrimack
Department of Public Works
6 Baboosic Lake Road
Merrimack, NH 03054

CONSULTANT

AECOM
250 Apollo Drive
Chelmsford, MA 01824
978.905.2100 tel
www.aecom.com

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PROJECT NUMBER

60680349

SHEET TITLE

EXISTING CONDITIONS SHEET 1

SHEET NUMBER

V-01

NOTE:
1) SEE SHEET G-01 FOR GENERAL NOTES AND LEGEND.

AECOM

PROJECT
Baboosic Lake - Pine Knoll Shores Subdivision Drainage Study

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Town of Merrimack
Department of Public Works
6 Baboosic Lake Road
Merrimack, NH 03054

CONSULTANT
AECOM
250 Apollo Drive
Chelmsford, MA 01824
978.905.2100 tel
www.aecom.com

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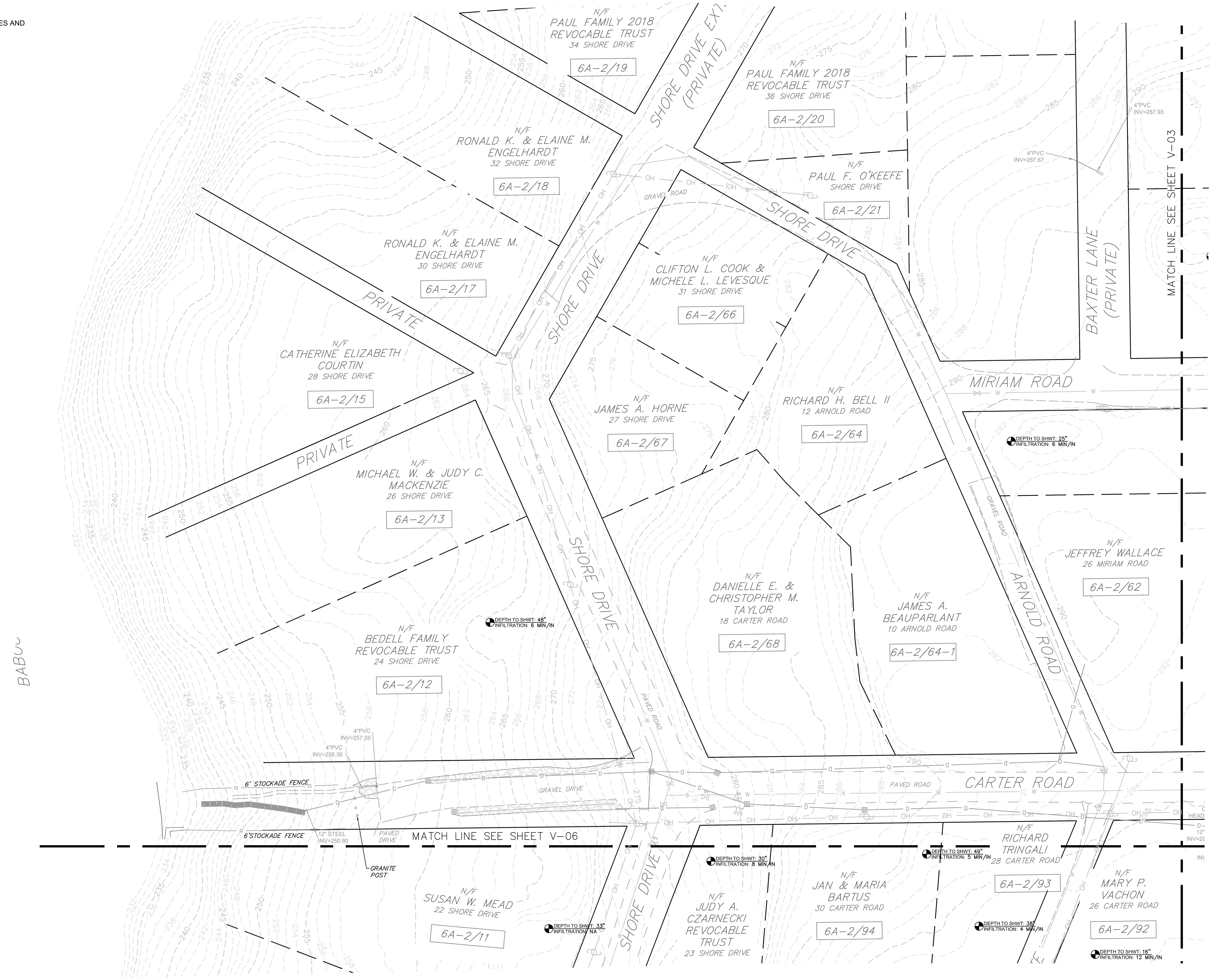
60680349

SHEET TITLE
EXISTING CONDITIONS SHEET 2

SHEET NUMBER
V-02

NOTE:

1) SEE SHEET G-01 FOR GENERAL NOTES AND LEGEND.



AECOM

PROJECT

Baboosic Lake - Pine Knoll Shores Subdivision Drainage Study

CLIENT

Town of Merrimack
Department of Public Works
6 Baboosic Lake Road
Merrimack, NH 03054

CONSULTANT

AECOM
250 Apollo Drive
Chelmsford, MA 01824
978.905.2100 tel
www.aecom.com

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PROJECT NUMBER

60680349

SHEET TITLE

EXISTING CONDITIONS SHEET 3

SHEET NUMBER

V-03

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NOTE:

1) SEE SHEET G-01 FOR GENERAL NOTES AND LEGEND.

AECOM

PROJECT

Baboosic Lake - Pine Knoll Shores Subdivision Drainage Study

CLIENT

Town of Merrimack
Department of Public Works
6 Baboosic Lake Road
Merrimack, NH 03054

CONSULTANT

AECOM
250 Apollo Drive
Chelmsford, MA 01824
978.905.2100 tel
www.aecom.com

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PROJECT NUMBER

60680349

SHEET TITLE

EXISTING CONDITIONS SHEET 4

SHEET NUMBER

V-04

NOTE:
1) SEE SHEET G-01 FOR GENERAL NOTES AND LEGEND.

AECOM

PROJECT
Baboosic Lake - Pine Knoll Shores Subdivision Drainage Study

CLIENT
Town of Merrimack
Department of Public Works
6 Baboosic Lake Road
Merrimack, NH 03054

CONSULTANT
AECOM
250 Apollo Drive
Chelmsford, MA 01824
978.905.2100 tel
www.aecom.com

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PROJECT NUMBER
60680349

SHEET TITLE
EXISTING CONDITIONS SHEET 5

SHEET NUMBER
V-05

NOTE:
1) SEE SHEET G-01 FOR GENERAL NOTES AND LEGEND.

AECOM

PROJECT
Baboosic Lake - Pine Knoll Shores Subdivision Drainage Study

CLIENT
Town of Merrimack
Department of Public Works
6 Baboosic Lake Road
Merrimack, NH 03054

CONSULTANT
AECOM
250 Apollo Drive
Chelmsford, MA 01824
978.905.2100 tel
www.aecom.com

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PROJECT NUMBER
60680349

SHEET TITLE
EXISTING CONDITIONS SHEET 6

SHEET NUMBER
V-06

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NOTE:

1) SEE SHEET G-01 FOR GENERAL NOTES AND LEGEND.

AECOM

PROJECT

Baboosic Lake - Pine Knoll Shores Subdivision Drainage Study

CLIENT

Town of Merrimack
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Merrimack, NH 03054

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250 Apollo Drive
Chelmsford, MA 01824
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PROJECT NUMBER

60680349

SHEET TITLE

EXISTING CONDITIONS
SHEET 7

SHEET NUMBER

V-07

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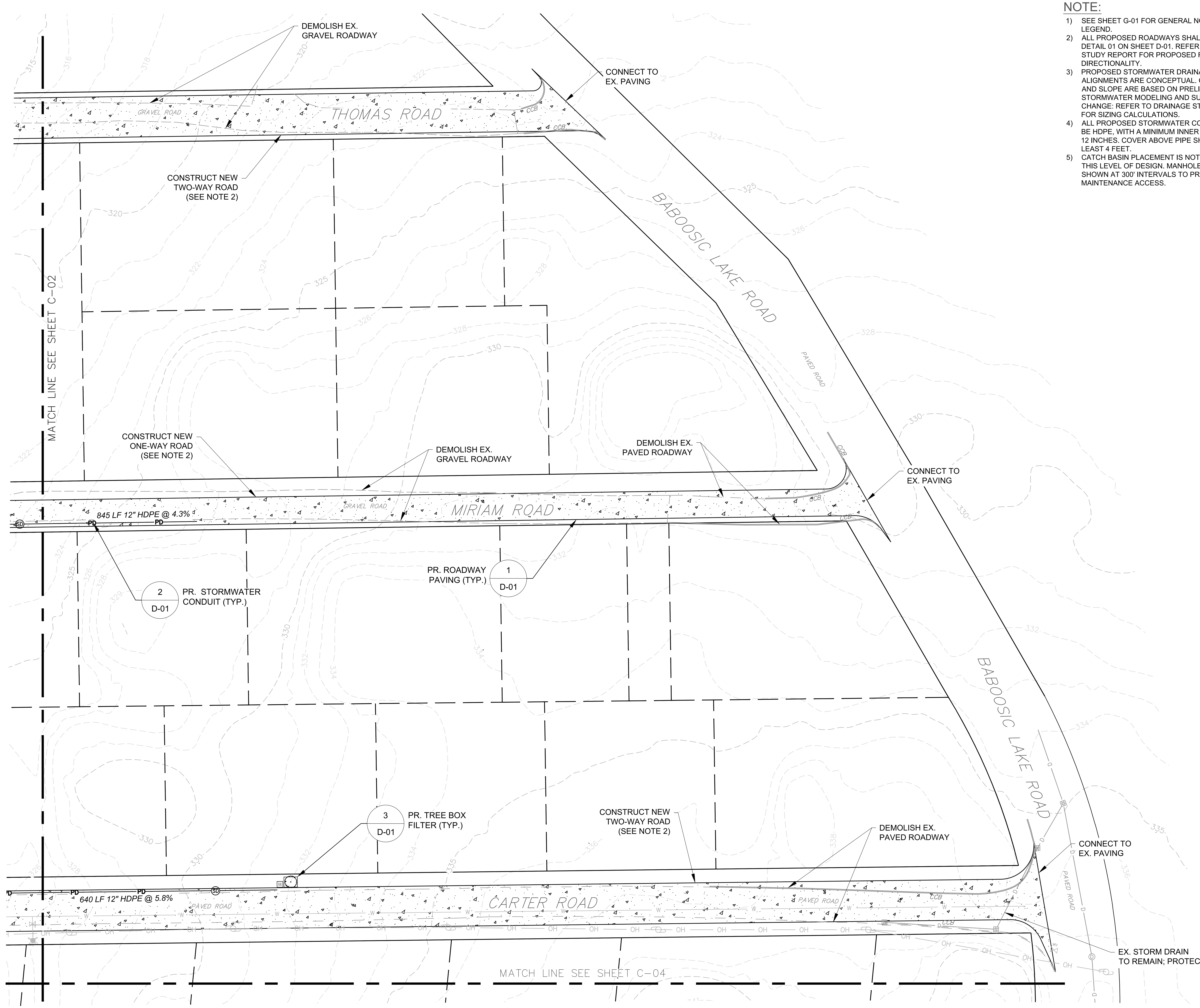

NOTE:

1) SEE SHEET G-01 FOR GENERAL NOTES AND LEGEND.
2) ALL PROPOSED ROADWAYS SHALL BE PAVED PER DETAIL 01 ON SHEET D-01. REFER TO DRAINAGE STUDY REPORT FOR PROPOSED ROADWAY DIRECTIONALITY.
3) PROPOSED STORMWATER DRAINAGE ALIGNMENTS ARE CONCEPTUAL. CONDUIT SIZING AND SLOPE ARE BASED ON PRELIMINARY STORMWATER MODELING AND SUBJECT TO CHANGE: REFER TO DRAINAGE STUDY REPORT FOR SIZING CALCULATIONS.
4) ALL PROPOSED STORMWATER CONDUIT SHALL BE HDPE, WITH A MINIMUM INNER DIAMETER OF 12 INCHES. COVER ABOVE PIPE SHALL BE AT LEAST 4 FEET.
5) CATCH BASIN PLACEMENT IS NOT INCLUDED AT THIS LEVEL OF DESIGN. MANHOLE PLACEMENT SHOWN AT 300' INTERVALS TO PROVIDE MAINTENANCE ACCESS.

AECOM

PROJECT
Baboosic Lake - Pine Knoll Shores Subdivision Drainage Study

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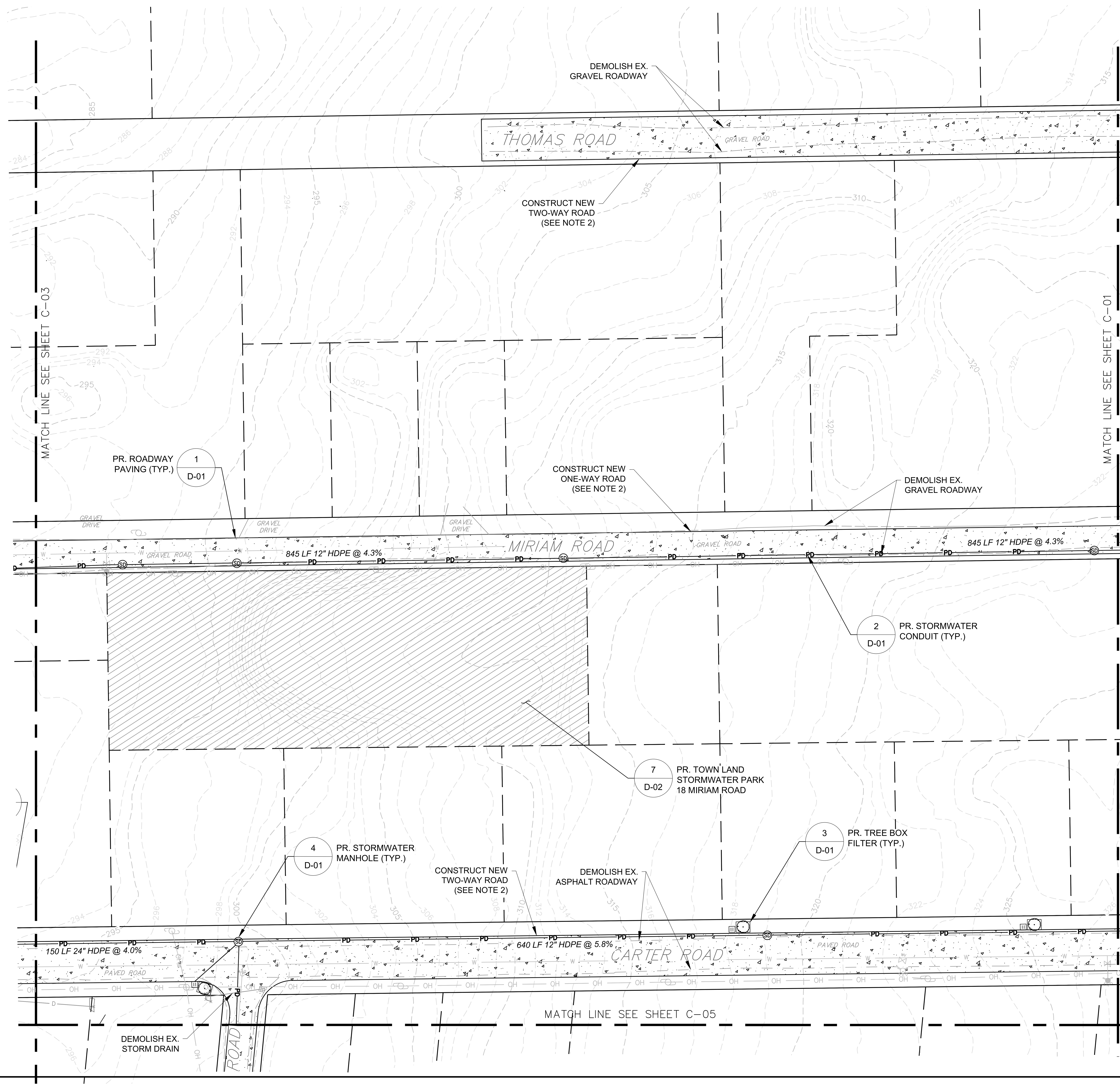
B	11/09/2022	CONCEPT DESIGN
A	9/30/2022	ISSUE FOR REVIEW

PROJECT NUMBER
60680349

SHEET TITLE
CONCEPT DESIGN
SHEET 1

SHEET NUMBER
C-01

NOTE:
1) SEE SHEET G-01 FOR GENERAL NOTES AND LEGEND.
2) ALL PROPOSED ROADWAYS SHALL BE PAVED PER DETAIL 01 ON SHEET D-01. REFER TO DRAINAGE STUDY REPORT FOR PROPOSED ROADWAY DIRECTIONALITY.
3) PROPOSED STORMWATER DRAINAGE ALIGNMENTS ARE CONCEPTUAL. CONDUIT SIZING AND SLOPE ARE BASED ON PRELIMINARY STORMWATER MODELING AND SUBJECT TO CHANGE: REFER TO DRAINAGE STUDY REPORT FOR SIZING CALCULATIONS.
4) ALL PROPOSED STORMWATER CONDUIT SHALL BE HDPE, WITH A MINIMUM INNER DIAMETER OF 12 INCHES. COVER ABOVE PIPE SHALL BE AT LEAST 4 FEET.
5) CATCH BASIN PLACEMENT IS NOT INCLUDED AT THIS LEVEL OF DESIGN. MANHOLE PLACEMENT SHOWN AT 300' INTERVALS TO PROVIDE MAINTENANCE ACCESS.



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PROJECT
Baboosic Lake - Pine Knoll Shores Subdivision Drainage Study

CLIENT
Town of Merrimack
Department of Public Works
6 Baboosic Lake Road
Merrimack, NH 03054

CONSULTANT
AECOM
250 Apollo Drive
Chelmsford, MA 01824
978.905.2100 tel
www.aecom.com

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SHEET TITLE
CONCEPT DESIGN
SHEET 3

SHEET NUMBER
C-02

NOTE:

1) SEE SHEET G-01 FOR GENERAL NOTES AND LEGEND.
2) ALL PROPOSED ROADWAYS SHALL BE PAVED PER DETAIL 01 ON SHEET D-01. REFER TO DRAINAGE STUDY REPORT FOR PROPOSED ROADWAY DIRECTIONALITY.
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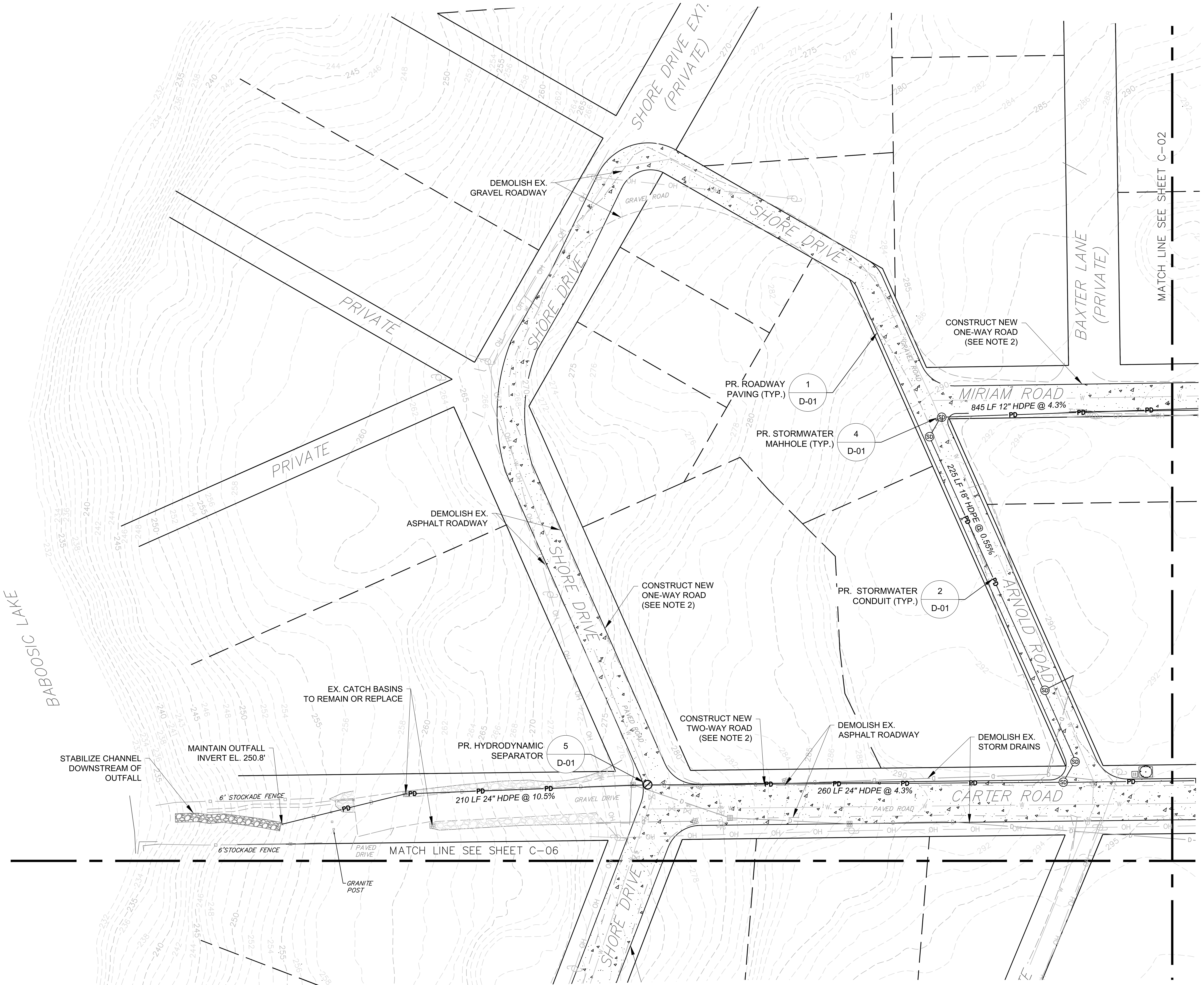

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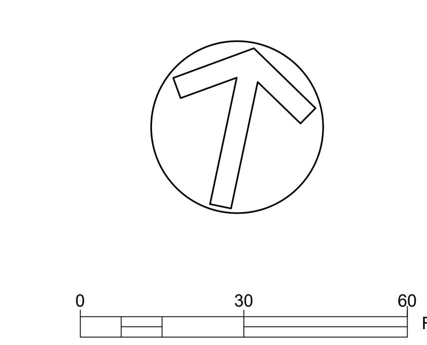

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SHEET TITLE

CONCEPT DESIGN
SHEET 3

SHEET NUMBER

C-03

NOTE:

1) SEE SHEET G-01 FOR GENERAL NOTES AND LEGEND.
2) ALL PROPOSED ROADWAYS SHALL BE PAVED PER DETAIL 01 ON SHEET D-01. REFER TO DRAINAGE STUDY REPORT FOR PROPOSED ROADWAY DIRECTIONALITY.
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SHEET TITLE

CONCEPT DESIGN
SHEET 4

SHEET NUMBER

C-04

NOTE:

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2) ALL PROPOSED ROADWAYS SHALL BE PAVED PER DETAIL 01 ON SHEET D-01. REFER TO DRAINAGE STUDY REPORT FOR PROPOSED ROADWAY DIRECTIONALITY.
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SHEET TITLE

CONCEPT DESIGN
SHEET 5

SHEET NUMBER

C-05

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SHEET TITLE

CONCEPT DESIGN
SHEET 6

SHEET NUMBER

C-06

NOTE:

1) SEE SHEET G-01 FOR GENERAL NOTES AND LEGEND.
2) ALL PROPOSED ROADWAYS SHALL BE PAVED PER DETAIL 01 ON SHEET D-01. REFER TO DRAINAGE STUDY REPORT FOR PROPOSED ROADWAY DIRECTIONALITY.
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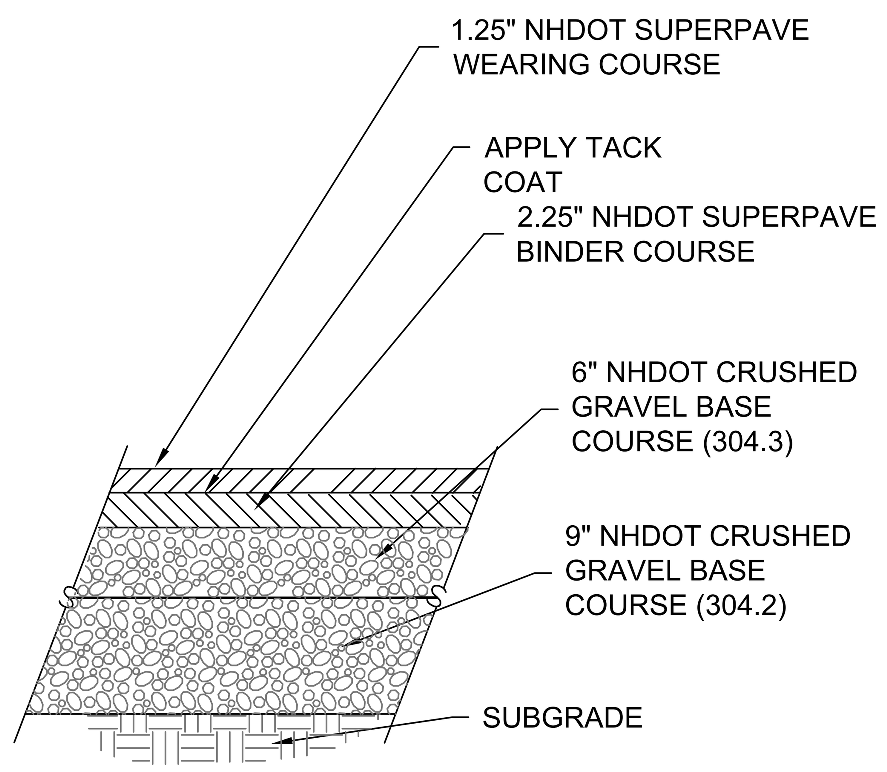
SHEET TITLE

CONCEPT DESIGN
SHEET 7

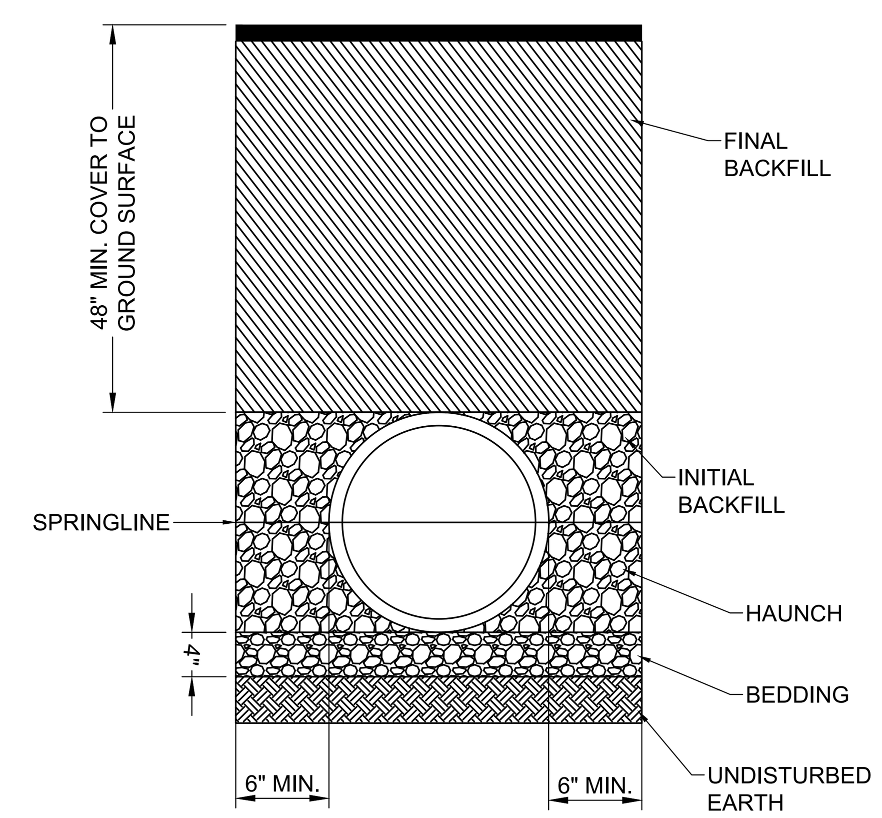
SHEET NUMBER

C-07



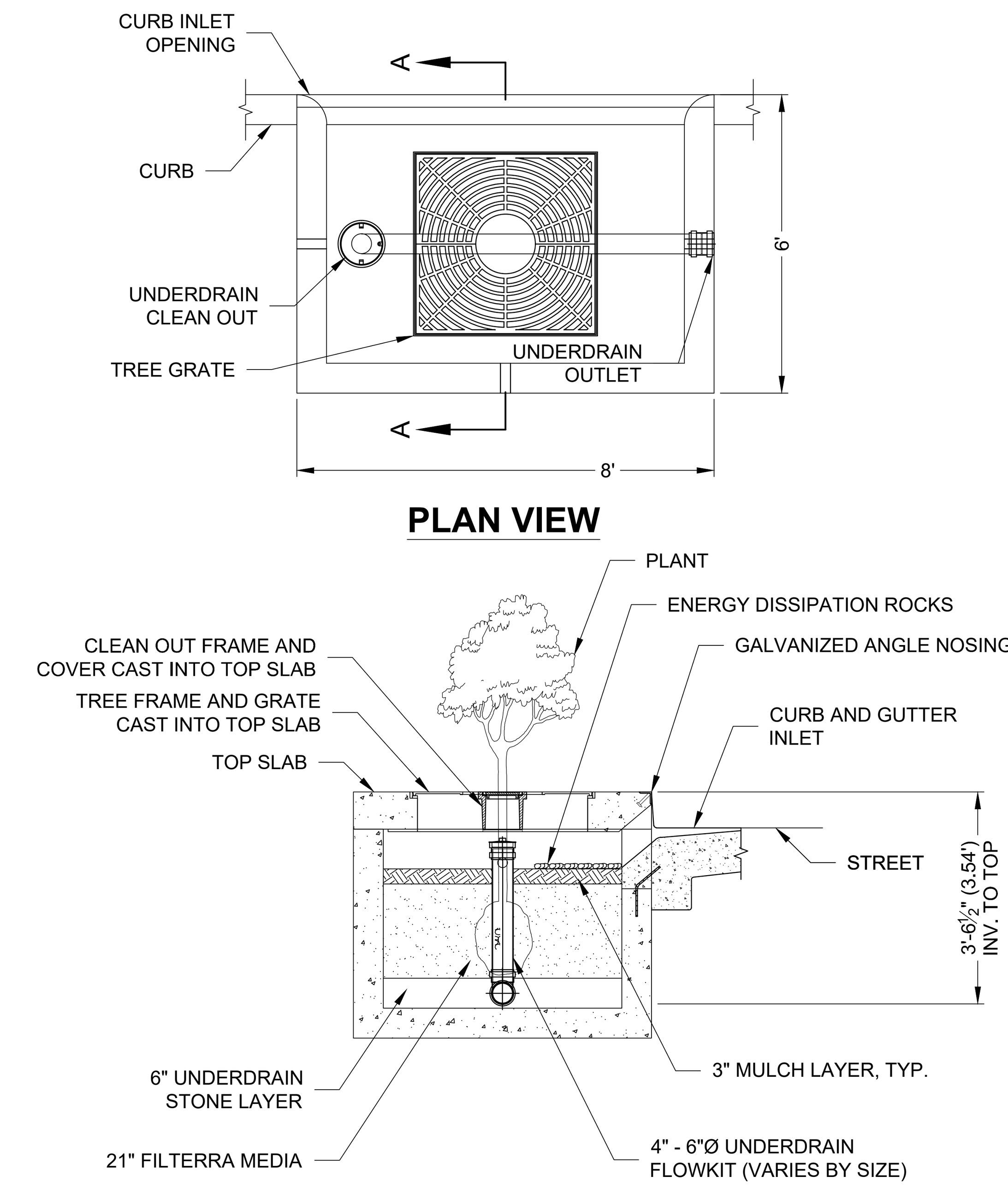
NOTES:
1. PAVING MATERIALS AND WORKMANSHIP SHALL MEET THE REQUIREMENTS OF THE APPLICABLE STATE OF NEW HAMPSHIRE DEPARTMENT OF TRANSPORTATION (NHDOT) SPECIFICATIONS AND STANDARDS.
2. ALL WORK SHALL CONFORM TO THE TOWN OF MERRIMACK DEPARTMENT OF PUBLIC WORKS CONSTRUCTION STANDARDS. AS WELL AS SECTION V OF THE TOWN OF MERRIMACK CONSTRUCTION STANDARDS.
3.

1 - ROADWAY PAVING
SCALE: NTS



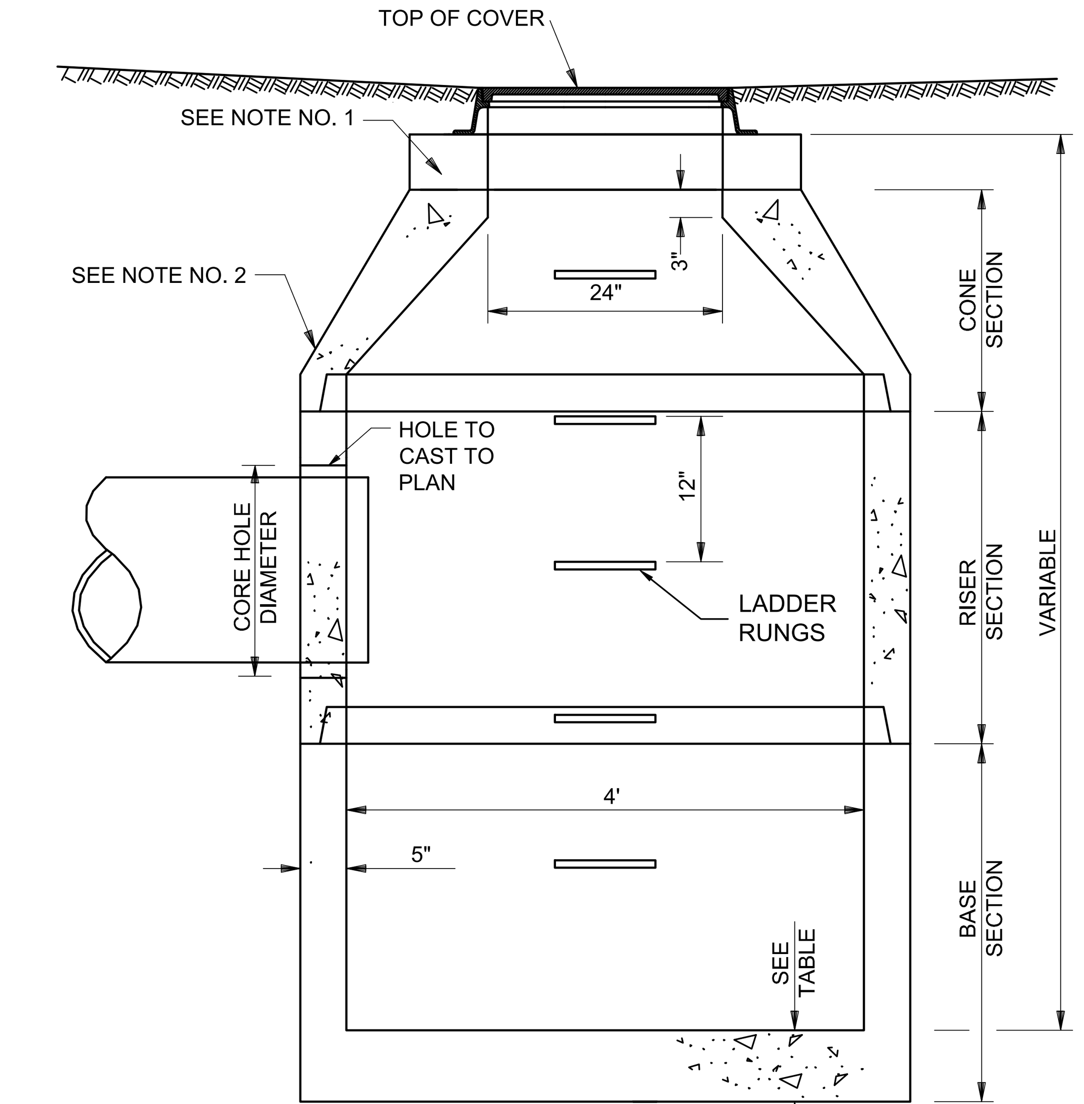
NOTES:
1. ALL PIPE SYSTEMS SHALL BE INSTALLED IN ACCORDANCE WITH ASTM D2321, "STANDARD PRACTICE FOR UNDERGROUND INSTALLATION OF THERMOPLASTIC PIPE FOR SEWERS AND OTHER GRAVITY FLOW APPLICATIONS", LATEST EDITION.
2. BEDDING: SUITABLE MATERIAL SHALL BE CLASS I, II OR III. THE CONTRACTOR SHALL PROVIDE DOCUMENTATION FOR MATERIAL SPECIFICATION TO ENGINEER. MINIMUM BEDDING THICKNESS SHALL BE 4" (100mm) FOR 4"-24" PIPE.
3. INITIAL BACKFILL: SUITABLE MATERIAL SHALL BE CLASS I, II OR III IN THE PIPE ZONE EXTENDING TO THE CROWN OF PIPE. MATERIAL SHALL BE INSTALLED AS REQUIRED IN ASTM D2321, LATEST EDITION.
4. MINIMUM COVER OVER ALL PIPING 48" FROM TOP OF PIPE TO GROUND SURFACE.

2 - TYPICAL PIPE INSTALLATION
SCALE: NTS



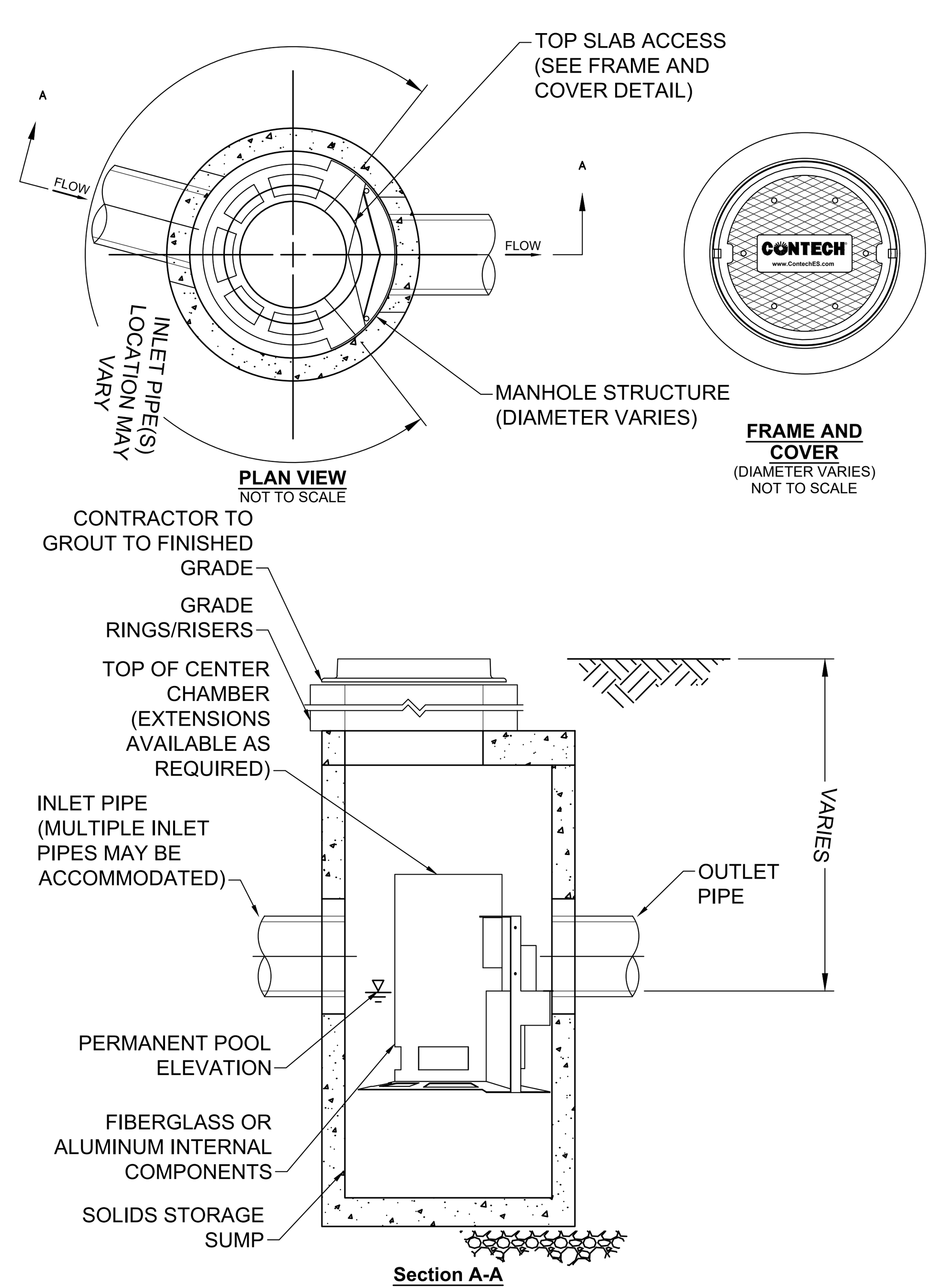
NOTES:
1. PLANT, MULCH, FILTERRA MEDIA, UNDERDRAIN KIT, AND UNDERDRAIN MATERIAL PROVIDED BY CONTECH.
2. PEAK FLOW BYPASS CONVEYANCE PROVIDED BY CATCH BASIIN PLACED IMMEDIATELY DOWNSTREAM OF FILTERRA UNIT.

3 - TYPICAL TREE BOX FILTER
SCALE: NTS

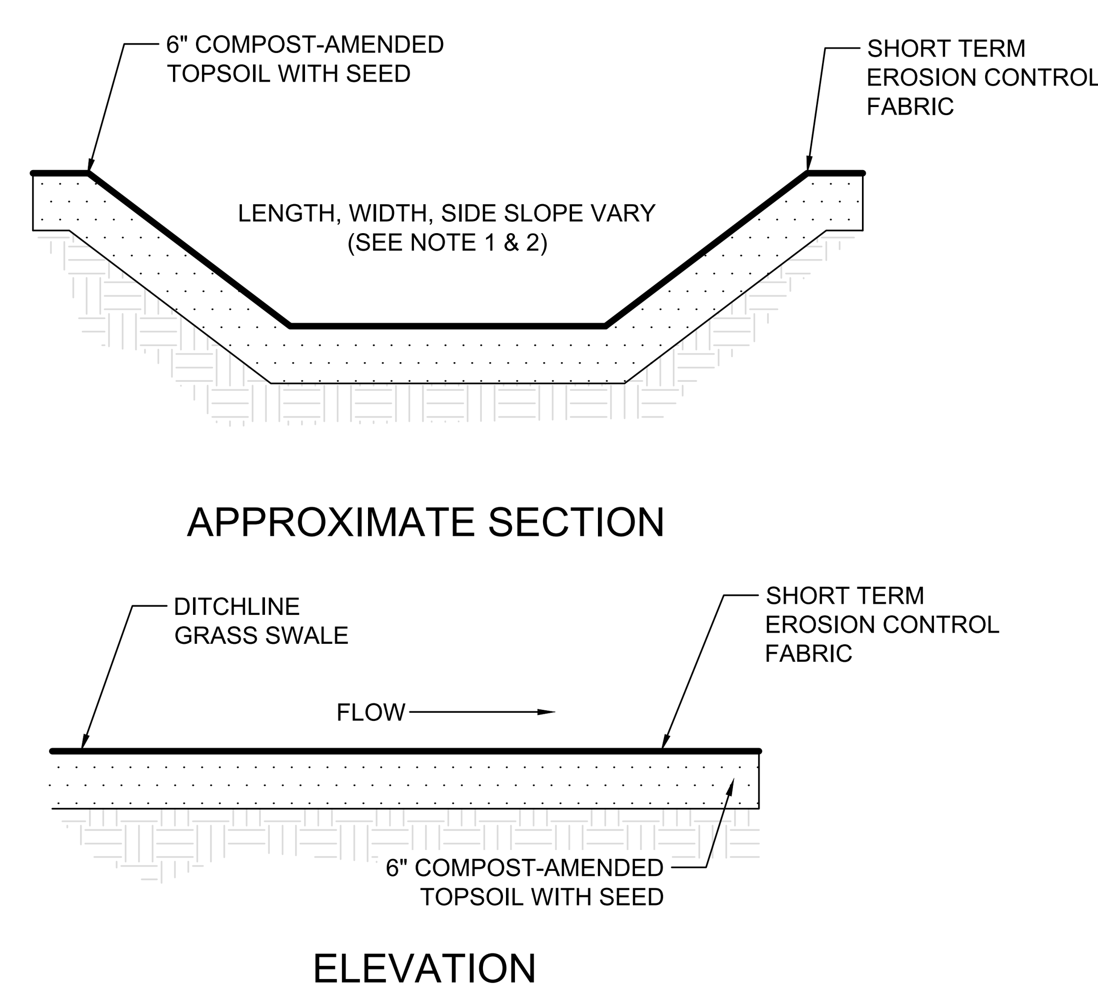


NOTES:
1. FITTING FRAME TO GRADE MAY BE DONE WITH PREFABRICATED ADJUSTMENT RINGS OR CLAY BRICKS (2 COURSES MAX.).
1. CONE SECTIONS MAY BE EITHER CONCENTRIC OR ECCENTRIC, OR FLAT SLAB TOPS MAY BE USED WHERE PIPE WOULD OTHERWISE ENTER INTO THE CONE SECTION OF THE STRUCTURE AND WHERE PERMITTED.
2. OUTSIDE EDGES OF PIPES SHALL PROJECT NO MORE THAN 3" BEYOND INSIDE WALL OF STRUCTURE.
3. PRECAST SECTIONS SHALL HAVE A TONGUE AND GROOVE JOINT 4" HIGH AT AN 11° ANGLE CENTERED IN THE WIDTH OF THE WALL AND SHALL BE ASSEMBLED USING AN APPROVED FLEXIBLE SEALANT IN JOINTS.
4. ALL STRUCTURES WILL HAVE A MINIMUM 3' SUMP BELOW LOWEST-INVERT CONDUIT.

4 - TYPICAL STORMWATER MANHOLE
SCALE: NTS



5 - TYPICAL HYDRODYNAMIC SEPARATOR
SCALE: NTS



NOTES:
1. ALL CONVEYANCE SWALES SHALL BE SIZED TO SAFELY CONVEY THE 25-YEAR STORM WITHOUT OVERTOPPING;L AND THE 10-YEAR STORM WITH 12" OF FREEBOARD.
2. TREATMENT SWALE ALONG LONGA ROAD SHALL BE SIZED PER THE NEW HAMPSHIRE STORMWATER MANUAL, VOLUME 2., SECTION 4.3.5. DIMENSIONS SHOWN ON PLAN ARE APPROXIMATE BASED ON PRELIMINARY HYDRAULIC ANALYSIS.
2. PRETREATMENT SWALE ALONG LONGA ROAD SHALL BE SIZED PER THE NEW HAMPSHIRE STORMWATER MANUAL, VOLUME 2., SECTION 4.4.3. DIMENSIONS SHOWN ON PLAN ARE APPROXIMATE BASED ON PRELIMINARY HYDRAULIC ANALYSIS.
3. SWALE LONGITUDINAL SLOPE SHALL NOT EXCEED 5%. CHECK DAMS SHALL BE INSTALLED WHERE LONGITUDINAL SLOPES EXCEED 2%.
4. BOTTOM OF ALL CONVEYANCE SWALES SHALL BE ABOVE THE SHWT.

6 - TYPICAL CONVEYANCE SWALE
SCALE: NTS

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PROJECT

Baboosic Lake - Pine Knoll Shores Subdivision Drainage Study

CLIENT

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CONSULTANT

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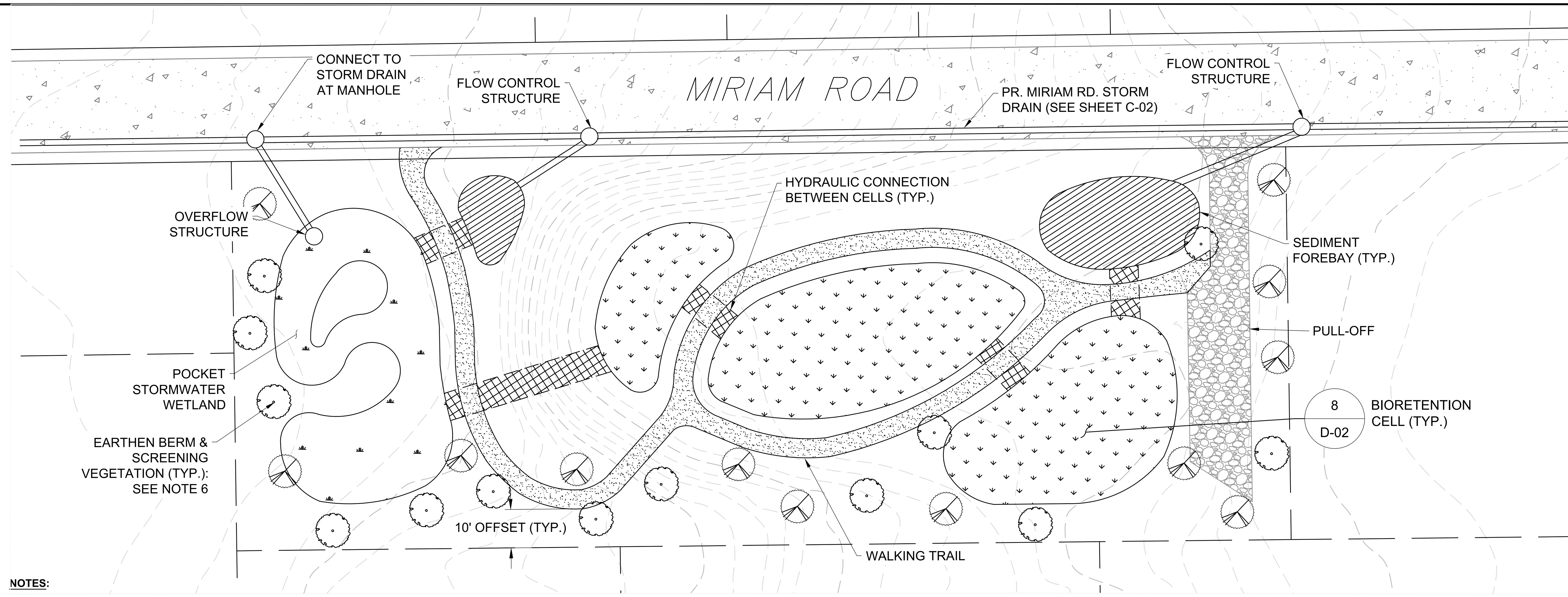
SHEET TITLE

CONCEPT DESIGN
DETAILS
SHEET 1

SHEET NUMBER

D-01

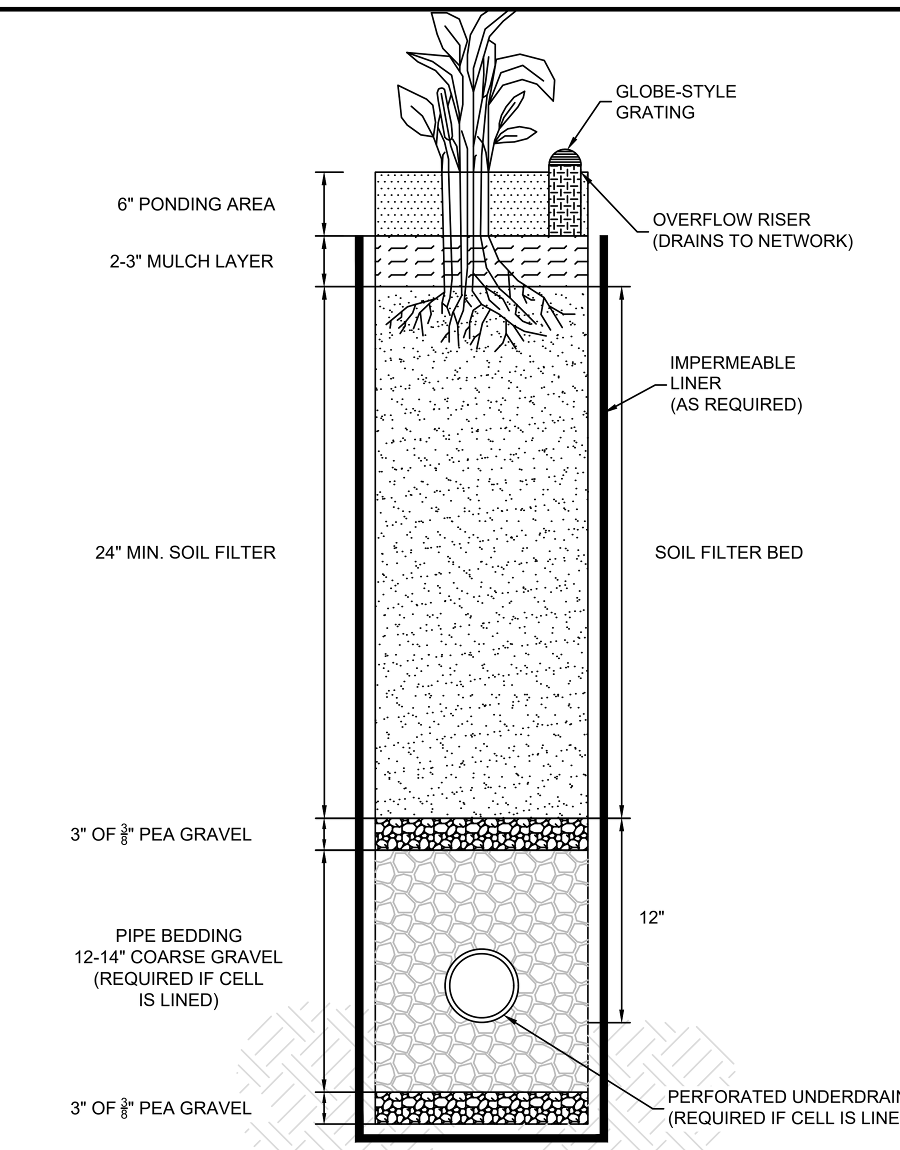


NOTES:

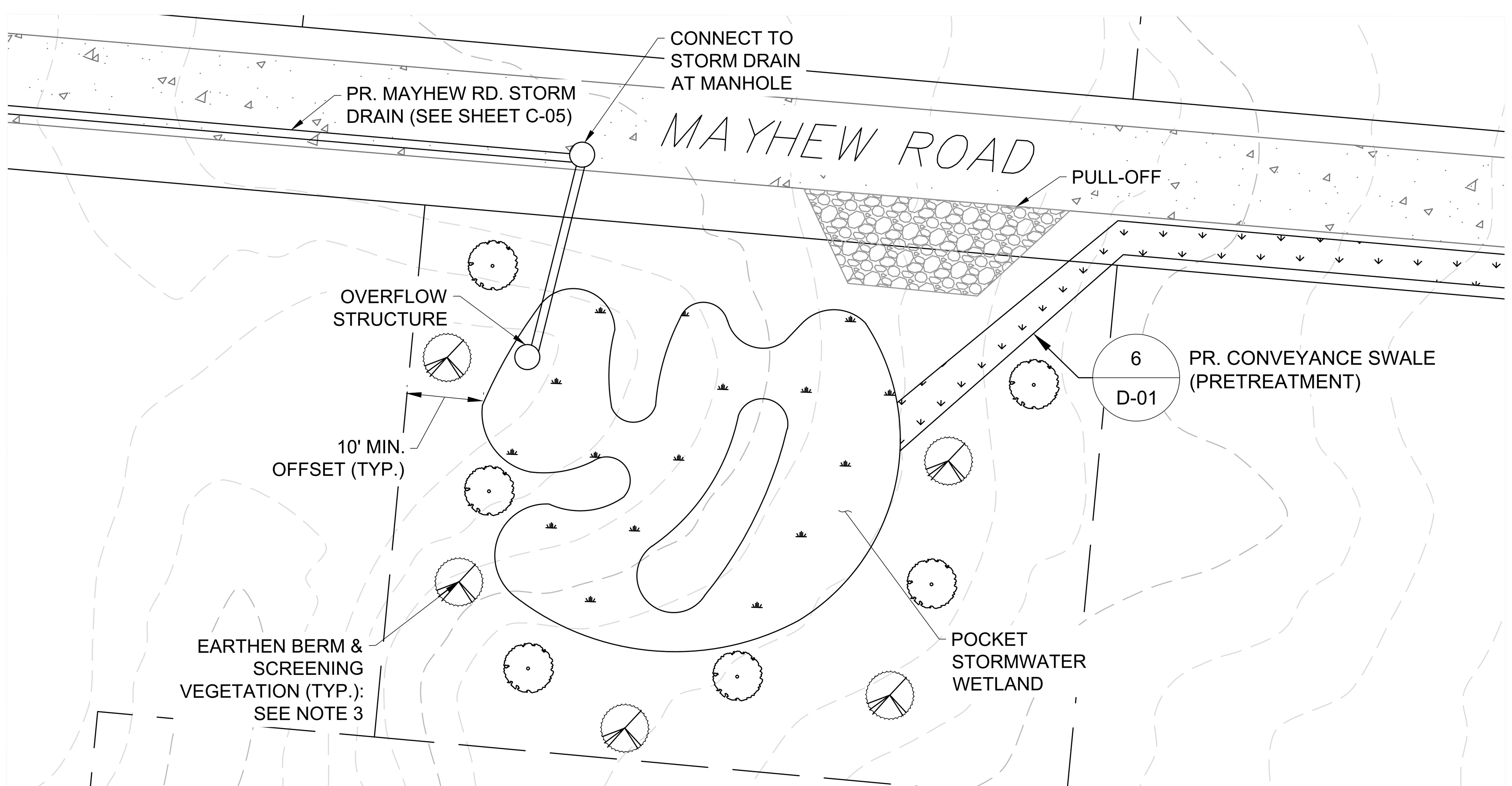
1. STORMWATER WETLANDS SHALL BE SIZED TO PROVIDE TREATMENT TO THE MAXIMUM EXTENT PRACTICABLE, FOLLOWING VOLUME 2, SECTION 4.3.2 OF THE NEW HAMPSHIRE STORMWATER MANUAL.
2. BIORETENTION CELLS SHALL BE DESIGNED FOLLOWING VOLUME 2, SECTION 4.3.4C OF THE NEW HAMPSHIRE STORMWATER MANUAL.
3. FLOW DIVERSION STRUCTURES SHALL BE USED TO DIRECT LOW FLOWS INTO PARK SYSTEMS WHILE BYPASSING HIGH FLOWS TOWARDS THE CARTER ROAD OUTFALL.
4. MINIMUM 10-FOOT SETBACK SHALL BE USED ALONG ALL ABUTTING PARCEL LIMITS FOR ALL PARK TRAILS AND STORMWATER FEATURES.
5. EDUCATIONAL SIGNAGE (NOT SHOWN HERE) TO BE INSTALLED ALONG WALKING TRAILS.
6. 2' BERM AND SCREENING VEGETATION MAY BE PROVIDED ALONG 10' BUFFER TO PROVIDE VISUAL AND STORMWATER BUFFERS FROM ABUTTING PROPERTIES AS NEEDED OR DETERMINED NECESSARY BY ENGINEER.
7. PLANTINGS AS SHOWN DEMONSTRATE CONCEPTUAL SCREENING AND DO NOT REFLECT FINAL LANDSCAPE DESIGN.

0 20 40 Feet

7 - PR. TOWN LAND STORMWATER PARK: 18 MIRIAM ROAD
1" = 20'



8 - BIORETENTION CELL SOIL COLUMN
SCALE: NTS



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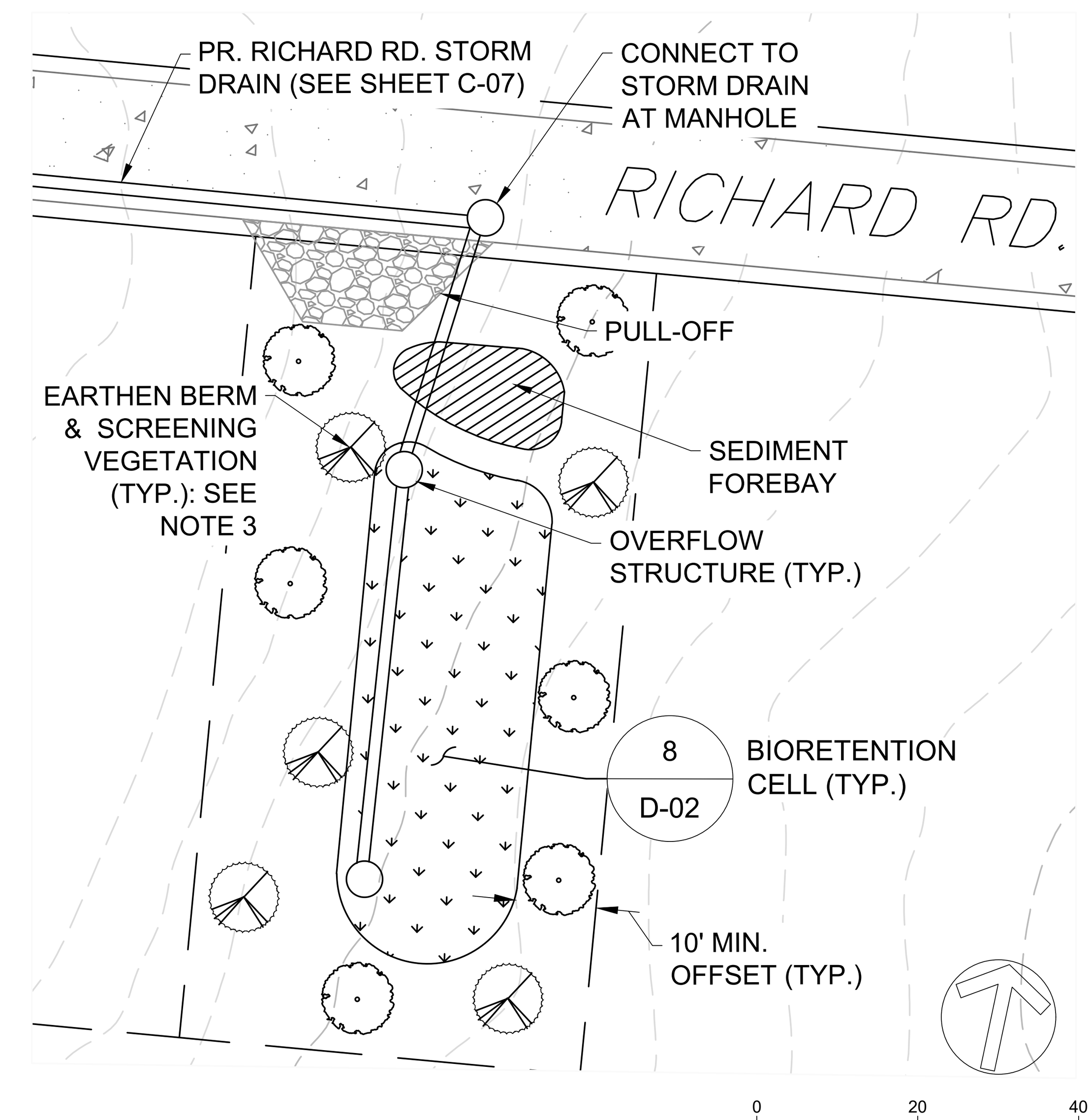
2. MINIMUM 10-FOOT SETBACK SHALL BE USED ALONG ALL ABUTTING PARCEL LIMITS FOR ALL BMP FEATURES.
3. 2' BERM AND SCREENING VEGETATION MAY BE PROVIDED ALONG 10' BUFFER TO PROVIDE VISUAL AND STORMWATER BUFFERS FROM ABUTTING PROPERTIES AS NEEDED OR DETERMINED NECESSARY BY ENGINEER.
4. PLANTINGS AS SHOWN DEMONSTRATE CONCEPTUAL SCREENING AND DO NOT REFLECT FINAL LANDSCAPE DESIGN.

0 20 40 Feet

9 - PR. TOWN LAND STORMWATER BMP: 12 MAYHEW ROAD
1" = 20'



0 20 40 Feet

NOTES:

1. BIORETENTION CELL AND SEDIMENT FOREBAY SHALL BE DESIGNED FOLLOWING VOL. 2, SECTION 4.3.4C AND VOL. 2, SECTION 4.4.1 OF THE NEW HAMPSHIRE STORMWATER MANUAL, RESPECTIVELY.
2. MINIMUM 10-FOOT SETBACK SHALL BE USED ALONG ALL ABUTTING PARCEL LIMITS FOR ALL BMP FEATURES.
3. 2' BERM AND SCREENING VEGETATION MAY BE PROVIDED ALONG 10' BUFFER TO PROVIDE VISUAL AND STORMWATER BUFFERS FROM ABUTTING PROPERTIES AS NEEDED OR DETERMINED NECESSARY BY ENGINEER.
4. PLANTINGS AS SHOWN DEMONSTRATE CONCEPTUAL SCREENING AND DO NOT REFLECT FINAL LANDSCAPE DESIGN.

10 - PR. TOWN LAND STORMWATER BMP: 5 RICHARD ROAD
1" = 20'

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PROJECT

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SHEET TITLE

CONCEPT DESIGN DETAILS SHEET 2

SHEET NUMBER

D-02

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Appendix D – Washoff Model Files & Documentation

Date (MM/DD/YYYY):	**7/15/2022**	
Project Name:	**Pike Knoll Shores Drainage Study**	
Town/City:	**Merrimack, NH**	
Impacted Surface Waters:	**Baboosic Lake**	
Applicant:		
DES File #:		

Average Annual Precipitation P	**43.34**	**inches**	**ONLY INPUT VALUES IN BLUE SHADED CELLS**
Fraction of Annual Runoff events that produce runoff	**0.90**	**(usually 0.9)**	

Credit for Using Low Nutrient Fertilizer: If there are managed turf areas under post development conditions that are to be fertilized annually, reductions in post development nutrient (TP and TN) loadings can be realized by by providing enforceable documents (i.e., deed restrictions) requiring land owners to use low nutrient fertilizer. To get low nutrient fertilizer pollutant reductions input the proposed reduced fertilizer application rates for post development development for TP and TN in the table below. Low nutrient fertilizers must have application rates less than the standard fertilizer application rate shown in the table. Then input the percent of each land use in each post development sub-area that is managed turf that is fertilzed annually.

	Fertilizer Reduction Calculator	
	TP	**TN**
STANDARD FERTILIZER APPLICATION RATE (lbs/acre/year)	15.0	150.0
PROPOSED REDUCED FERTILIZER APPLICATION RATES FOR POST-DEVELOPMENT (lbs/acre/year)	**15.0**	**150.0**
INITIAL PERCENT REDUCTION	0.0%	0.0%
PERCENT OF CITIZENS THAT WILL COMPLY WITH REDUCED APPLICATION RATES	50%	50%
PERCENT OF APPLIED FERTILIZER THAT IS LOST TO RUNOFF OR PERCOLATION	10%	10%
FINAL PERCENT FERTILIZER REDUCTION WITH COMPLIANCE AND RUNOFF RATES APPLIED (%FR	**0.0%**	**0.0%**
MINIMUM ASSUMED EMC = EMC_{MIN} (mg/L)	0.11	1.74

← **Used to reduce EMCs for Post TP and Post TN for each land use in each Sub Area depending on perce of area that is managed turf that is fertilized annually**

PRE-DEVELOPMENT CONDITIONS

	Area	Impervious Area
Total Area (All Sub-Areas) (acres)	**57.01**	**7.25**

Insert information for 1st sub-area below

Sub_Area_ID	**Arnold**	
Point of Analysis (PoA) Number	**2**	
Total Area for Sub-Area (acres)	**2.57**	**0.30**

Land Use	Area	Ia
	(acres)	(% Impervious)
From HWG		
Residential Roof	0.22	100.00%
Commercial Roof	0.00	0.00%
Commercial/Res Parking	0.00	0.00%
Residential Street	0.00	100.00%
Urban Highway	0.00	0.00%
Lawns	0.26	0.00%
Driveway	0.14	0.00%
Residential (general)	0.00	0.00%
Commercial (general)	0.00	0.00%
Industrial (general)	0.00	0.00%
From CDM		
Agriculture and Pasture	0.00	0.00%
Commercial	0.00	0.00%
Forest/Rural Open	1.87	0.00%
Highway	0.00	0.00%
Industrial	0.00	0.00%

POST-DEVELOPMENT CONDITIONS

	Area	Impervious Area	Area Fertilized Annually
	57.01	**7.74**	**0.00**

Sub_Area_ID	**Arnold**		
Point of Analysis (PoA) Number	**2**		
Total Area in Sub-Area (acres)	**2.57**	**0.31**	**0.00**

Land Use	Total Area for each Land Use	Ia	Percent of Area that is managed turf (i.e., fertilized annually)	Post-TP EMC	Post-TN EMC
	(acres)	(% Impervious)	%	mg/L	mg/L
From HWG					
Residential Roof	0.22	100.00%	0.0%	0.11	1.50
Commercial Roof	0.00	0.00%	0.0%	0.14	2.10
Commercial/Res Parking	0.00	0.00%	0.0%	0.15	1.90
Residential Street	0.08	100.00%	0.0%	0.55	1.40
Urban Highway	0.00	0.00%	0.0%	0.32	3.00
Lawns	0.26	0.00%	0.0%	2.10	9.10
Driveway	0.14	0.00%	0.0%	0.56	2.10
Residential (general)	0.00	0.00%	0.0%	0.40	2.20
Commercial (general)	0.00	0.00%	0.0%	0.20	2.00
Industrial (general)	0.00	0.00%	0.0%	0.40	2.50
From CDM					
Agriculture and Pasture	0.00	0.00%	0.0%	0.37	5.98
Commercial	0.00	0.00%	0.0%	0.33	2.97
Forest/Rural Open	1.86	0.00%	0.0%	0.11	1.74
Highway	0.00	0.00%	0.0%	0.43	2.65
Industrial	0.00	0.00%	0.0%	0.32	3.97

Medium Density Residential	0.00	0.00%
Urban Open	0.00	0.00%
Water/Wetland	0.00	0.00%
From Sheridan & Noske		
Gravel Road	0.07	100.00%

Medium Density Residential	0.00	0.00%	0.0%	0.52	5.15
Urban Open	0.00	0.00%	0.0%	0.11	1.74
Water/Wetland	0.00	0.00%	0.0%	0.08	1.38
From Sheridan & Noske					
Gravel Road	0.00	100.00%	0.0%	0.55	1.40

Insert information for 2nd sub-area below

Sub_Area_ID	**Carter-E**	
Point of Analysis (PoA) Number	**2**	
Total Area for Sub-Area (acres)	**3.69**	**0.70**

Land Use	**Area** (acres)	**Ia** (% Impervious)
From HWG		
Residential Roof	0.36	100.00%
Commercial Roof	0.00	0.00%
Commercial/Res Parking	0.00	0.00%
Residential Street	0.33	100.00%
Urban Highway	0.00	0.00%
Lawns	0.54	0.00%
Driveway	0.28	0.00%
Residential (general)	0.00	0.00%
Commercial (general)	0.00	0.00%
Industrial (general)	0.00	0.00%
From CDM		
Agriculture and Pasture	0.00	0.00%
Commercial	0.00	0.00%
Forest/Rural Open	2.17	0.00%
Highway	0.00	0.00%
Industrial	0.00	0.00%
Medium Density Residential	0.00	0.00%
Urban Open	0.00	0.00%
Water/Wetland	0.00	0.00%
From Sheridan & Noske		
Gravel Road	0.01	100.00%

Sub_Area_ID	**Carter-E**		
Point of Analysis (PoA) Number	**2**		
Total Area in Sub-Area (acres)	**3.69**	**0.81**	**0.00**

Land Use	**Area** (acres)	**Ia** (% Impervious)	**Percent of Area that is managed turf (i.e., fertilized annually)** %	**Post-TP EMC** mg/L	**Post-TN EMC** mg/L
From HWG					
Residential Roof	0.36	100.00%	0.0%	0.11	1.50
Commercial Roof	0.00	0.00%	0.0%	0.14	2.10
Commercial/Res Parking	0.00	0.00%	0.0%	0.15	1.90
Residential Street	0.45	100.00%	0.0%	0.55	1.40
Urban Highway	0.00	0.00%	0.0%	0.32	3.00
Lawns	0.53	0.00%	0.0%	2.10	9.10
Driveway	0.26	0.00%	0.0%	0.56	2.10
Residential (general)	0.00	0.00%	0.0%	0.40	2.20
Commercial (general)	0.00	0.00%	0.0%	0.20	2.00
Industrial (general)	0.00	0.00%	0.0%	0.40	2.50
From CDM					
Agriculture and Pasture	0.00	0.00%	0.0%	0.37	5.98
Commercial	0.00	0.00%	0.0%	0.33	2.97
Forest/Rural Open	2.10	0.00%	0.0%	0.11	1.74
Highway	0.00	0.00%	0.0%	0.43	2.65
Industrial	0.00	0.00%	0.0%	0.32	3.97
Medium Density Residential	0.00	0.00%	0.0%	0.52	5.15
Urban Open	0.00	0.00%	0.0%	0.11	1.74
Water/Wetland	0.00	0.00%	0.0%	0.08	1.38
From Sheridan & Noske					
Gravel Road	0.00	100.00%	0.0%	0.55	1.40

Insert information for 3rd sub-area below

Sub_Area_ID	**Lake-N**	
Point of Analysis (PoA) Number	**1**	
Total Area for Sub-Area (acres)	**12.27**	**1.47**

Land Use	**Area** (acres)	**Ia** (% Impervious)
From HWG		
Residential Roof	1.02	100.00%
Commercial Roof	0.00	0.00%
Commercial/Res Parking	0.00	0.00%
Residential Street	0.10	100.00%
Urban Highway	0.00	0.00%
Lawns	0.63	0.00%
Driveway	1.18	0.00%
Residential (general)	0.00	0.00%

Sub_Area_ID	**Lake-N**		
Point of Analysis (PoA) Number	**1**		
Total Area in Sub-Area (acres)	**12.27**	**1.57**	**0.00**

Land Use	**Area** (acres)	**Ia** (% Impervious)	**Percent of Area that is managed turf (i.e., fertilized annually)** %	**Post-TP EMC** mg/L	**Post-TN EMC** mg/L
From HWG					
Residential Roof	1.02	100.00%	0.0%	0.11	1.50
Commercial Roof	0.00	0.00%	0.0%	0.14	2.10
Commercial/Res Parking	0.00	0.00%	0.0%	0.15	1.90
Residential Street	0.45	100.00%	0.0%	0.55	1.40
Urban Highway	0.00	0.00%	0.0%	0.32	3.00
Lawns	0.63	0.00%	0.0%	2.10	9.10
Driveway	1.17	0.00%	0.0%	0.56	2.10
Residential (general)	0.00	0.00%	0.0%	0.40	2.20

	Area	Ia
Commercial (general)	0.00	0.00%
Industrial (general)	0.00	0.00%
From CDM		
Agriculture and Pasture	0.00	0.00%
Commercial	0.00	0.00%
Forest/Rural Open	8.99	0.00%
Highway	0.00	0.00%
Industrial	0.00	0.00%
Medium Density Residential	0.00	0.00%
Urban Open	0.00	0.00%
Water/Wetland	0.00	0.00%
From Sheridan & Noske		
Gravel Road	0.35	100.00%

	Area	Ia	%	Post-TP EMC	Post-TN EMC
Commercial (general)	0.00	0.00%	0.0%	0.20	2.00
Industrial (general)	0.00	0.00%	0.0%	0.40	2.50
From CDM					
Agriculture and Pasture	0.00	0.00%	0.0%	0.37	5.98
Commercial	0.00	0.00%	0.0%	0.33	2.97
Forest/Rural Open	8.90	0.00%	0.0%	0.11	1.74
Highway	0.00	0.00%	0.0%	0.43	2.65
Industrial	0.00	0.00%	0.0%	0.32	3.97
Medium Density Residential	0.00	0.00%	0.0%	0.52	5.15
Urban Open	0.00	0.00%	0.0%	0.11	1.74
Water/Wetland	0.00	0.00%	0.0%	0.08	1.38
From Sheridan & Noske					
Gravel Road	0.10	100.00%	0.0%	0.55	1.40

Insert information for 4th sub-area below

Sub_Area_ID	**Lake-S**	
Point of Analysis (PoA) Number	**4**	
Total Area for Sub-Area (acres)	**11.20**	**1.29**

Land Use	**Area** (acres)	**Ia** (% Impervious)
From HWG		
Residential Roof	0.90	100.00%
Commercial Roof	0.00	0.00%
Commercial/Res Parking	0.00	0.00%
Residential Street	0.25	100.00%
Urban Highway	0.00	0.00%
Lawns	0.50	0.00%
Driveway	0.89	0.00%
Residential (general)	0.00	0.00%
Commercial (general)	0.00	0.00%
Industrial (general)	0.00	0.00%
From CDM		
Agriculture and Pasture	0.00	0.00%
Commercial	0.00	0.00%
Forest/Rural Open	8.53	0.00%
Highway	0.00	0.00%
Industrial	0.00	0.00%
Medium Density Residential	0.00	0.00%
Urban Open	0.00	0.00%
Water/Wetland	0.00	0.00%
From Sheridan & Noske		
Gravel Road	0.14	100.00%

Sub_Area_ID	**Lake-S**		
Point of Analysis (PoA) Number	**4**		
Total Area in Sub-Area (acres)	**11.20**	**1.47**	**0.00**

Land Use	**Area** (acres)	**Ia** (% Impervious)	**Percent of Area that is managed turf (i.e., fertilized annually)** %	**Post-TP EMC** mg/L	**Post-TN EMC** mg/L
From HWG					
Residential Roof	0.90	100.00%	0.0%	0.11	1.50
Commercial Roof	0.00	0.00%	0.0%	0.14	2.10
Commercial/Res Parking	0.00	0.00%	0.0%	0.15	1.90
Residential Street	0.57	100.00%	0.0%	0.55	1.40
Urban Highway	0.00	0.00%	0.0%	0.32	3.00
Lawns	0.50	0.00%	0.0%	2.10	9.10
Driveway	0.87	0.00%	0.0%	0.56	2.10
Residential (general)	0.00	0.00%	0.0%	0.40	2.20
Commercial (general)	0.00	0.00%	0.0%	0.20	2.00
Industrial (general)	0.00	0.00%	0.0%	0.40	2.50
From CDM					
Agriculture and Pasture	0.00	0.00%	0.0%	0.37	5.98
Commercial	0.00	0.00%	0.0%	0.33	2.97
Forest/Rural Open	8.37	0.00%	0.0%	0.11	1.74
Highway	0.00	0.00%	0.0%	0.43	2.65
Industrial	0.00	0.00%	0.0%	0.32	3.97
Medium Density Residential	0.00	0.00%	0.0%	0.52	5.15
Urban Open	0.00	0.00%	0.0%	0.11	1.74
Water/Wetland	0.00	0.00%	0.0%	0.08	1.38
From Sheridan & Noske					
Gravel Road	0.00	100.00%	0.0%	0.55	1.40

Insert information for 5th sub-area below

Sub_Area_ID	**Longa**	
Point of Analysis (PoA) Number	**3**	
Total Area for Sub-Area (acres)	**3.67**	**0.56**

Land Use	**Area** (acres)	**Ia** (% Impervious)
From HWG		
Residential Roof	0.18	100.00%
Commercial Roof	0.00	0.00%

Sub_Area_ID	**Longa**		
Point of Analysis (PoA) Number	**3**		
Total Area in Sub-Area (acres)	**3.67**	**0.52**	**0.00**

Land Use	**Area** (acres)	**Ia** (% Impervious)	**Percent of Area that is managed turf (i.e., fertilized annually)** %	**Post-TP EMC** mg/L	**Post-TN EMC** mg/L
From HWG					
Residential Roof	0.18	100.00%	0.0%	0.11	1.50
Commercial Roof	0.00	0.00%	0.0%	0.14	2.10

Commercial/Res Parking	0.00	0.00%
Residential Street	0.00	100.00%
Urban Highway	0.00	0.00%
Lawns	0.31	0.00%
Driveway	0.12	0.00%
Residential (general)	0.00	0.00%
Commercial (general)	0.00	0.00%
Industrial (general)	0.00	0.00%
From CDM		
Agriculture and Pasture	0.00	0.00%
Commercial	0.00	0.00%
Forest/Rural Open	2.67	0.00%
Highway	0.00	0.00%
Industrial	0.00	0.00%
Medium Density Residential	0.00	0.00%
Urban Open	0.00	0.00%
Water/Wetland	0.00	0.00%
From Sheridan & Noske		
Gravel Road	0.38	100.00%

Commercial/Res Parking	0.00	0.00%	0.0%	0.15	1.90
Residential Street	0.34	100.00%	0.0%	0.55	1.40
Urban Highway	0.00	0.00%	0.0%	0.32	3.00
Lawns	0.29	0.00%	0.0%	2.10	9.10
Driveway	0.12	0.00%	0.0%	0.56	2.10
Residential (general)	0.00	0.00%	0.0%	0.40	2.20
Commercial (general)	0.00	0.00%	0.0%	0.20	2.00
Industrial (general)	0.00	0.00%	0.0%	0.40	2.50
From CDM					
Agriculture and Pasture	0.00	0.00%	0.0%	0.37	5.98
Commercial	0.00	0.00%	0.0%	0.33	2.97
Forest/Rural Open	2.74	0.00%	0.0%	0.11	1.74
Highway	0.00	0.00%	0.0%	0.43	2.65
Industrial	0.00	0.00%	0.0%	0.32	3.97
Medium Density Residential	0.00	0.00%	0.0%	0.52	5.15
Urban Open	0.00	0.00%	0.0%	0.11	1.74
Water/Wetland	0.00	0.00%	0.0%	0.08	1.38
From Sheridan & Noske					
Gravel Road	0.00	100.00%	0.0%	0.55	1.40

Insert information for 6th sub-area below

Sub_Area_ID	**Mayhew-E**	
Point of Analysis (PoA) Number	**3**	
Total Area for Sub-Area (acres)	**1.72**	**0.28**

Sub_Area_ID	**Mayhew-E**		
Point of Analysis (PoA) Number	**3**		
Total Area in Sub-Area (acres)	**1.72**	**0.28**	**0.00**

Land Use	**Area**	**Ia**
	(acres)	(% Impervious)
From HWG		
Residential Roof	0.09	100.00%
Commercial Roof	0.00	0.00%
Commercial/Res Parking	0.00	0.00%
Residential Street	0.00	100.00%
Urban Highway	0.00	0.00%
Lawns	0.29	0.00%
Driveway	0.13	0.00%
Residential (general)	0.00	0.00%
Commercial (general)	0.00	0.00%
Industrial (general)	0.00	0.00%
From CDM		
Agriculture and Pasture	0.00	0.00%
Commercial	0.00	0.00%
Forest/Rural Open	1.02	0.00%
Highway	0.00	0.00%
Industrial	0.00	0.00%
Medium Density Residential	0.00	0.00%
Urban Open	0.00	0.00%
Water/Wetland	0.00	0.00%
From Sheridan & Noske		
Gravel Road	0.19	100.00%

Land Use	**Area**	**Ia**	**Percent of Area that is managed turf (i.e., fertilized annually)**	**Post-TP EMC**	**Post-TN EMC**
	(acres)	(% Impervious)	%	mg/L	mg/L
From HWG					
Residential Roof	0.09	100.00%	0.0%	0.11	1.50
Commercial Roof	0.00	0.00%	0.0%	0.14	2.10
Commercial/Res Parking	0.00	0.00%	0.0%	0.15	1.90
Residential Street	0.19	100.00%	0.0%	0.55	1.40
Urban Highway	0.00	0.00%	0.0%	0.32	3.00
Lawns	0.29	0.00%	0.0%	2.10	9.10
Driveway	0.12	0.00%	0.0%	0.56	2.10
Residential (general)	0.00	0.00%	0.0%	0.40	2.20
Commercial (general)	0.00	0.00%	0.0%	0.20	2.00
Industrial (general)	0.00	0.00%	0.0%	0.40	2.50
From CDM					
Agriculture and Pasture	0.00	0.00%	0.0%	0.37	5.98
Commercial	0.00	0.00%	0.0%	0.33	2.97
Forest/Rural Open	1.03	0.00%	0.0%	0.11	1.74
Highway	0.00	0.00%	0.0%	0.43	2.65
Industrial	0.00	0.00%	0.0%	0.32	3.97
Medium Density Residential	0.00	0.00%	0.0%	0.52	5.15
Urban Open	0.00	0.00%	0.0%	0.11	1.74
Water/Wetland	0.00	0.00%	0.0%	0.08	1.38
From Sheridan & Noske					
Gravel Road	0.00	100.00%	0.0%	0.55	1.40

Insert information for 7th sub-area below

Sub_Area_ID	**Mayhew-W**	
Point of Analysis (PoA) Number	**3**	
Total Area for Sub-Area (acres)	**0.65**	**0.14**

Sub_Area_ID	**Mayhew-W**		
Point of Analysis (PoA) Number	**3**		
Total Area in Sub-Area (acres)	**0.65**	**0.15**	**0.00**

Land Use	Area (acres)	Ia (% Impervious)
From HWG		
Residential Roof	0.01	100.00%
Commercial Roof	0.00	0.00%
Commercial/Res Parking	0.00	0.00%
Residential Street	0.00	100.00%
Urban Highway	0.00	0.00%
Lawns	0.00	0.00%
Driveway	0.03	0.00%
Residential (general)	0.00	0.00%
Commercial (general)	0.00	0.00%
Industrial (general)	0.00	0.00%
From CDM		
Agriculture and Pasture	0.00	0.00%
Commercial	0.00	0.00%
Forest/Rural Open	0.48	0.00%
Highway	0.00	0.00%
Industrial	0.00	0.00%
Medium Density Residential	0.00	0.00%
Urban Open	0.00	0.00%
Water/Wetland	0.00	0.00%
From Sheridan & Noske		
Gravel Road	0.13	100.00%

Land Use	Area (acres)	Ia (% Impervious)	Percent of Area that is managed turf (i.e., fertilized annually) %	Post-TP EMC mg/L	Post-TN EMC mg/L
From HWG					
Residential Roof	0.01	100.00%	0.0%	0.11	1.50
Commercial Roof	0.00	0.00%	0.0%	0.14	2.10
Commercial/Res Parking	0.00	0.00%	0.0%	0.15	1.90
Residential Street	0.14	100.00%	0.0%	0.55	1.40
Urban Highway	0.00	0.00%	0.0%	0.32	3.00
Lawns	0.00	0.00%	0.0%	2.10	9.10
Driveway	0.02	0.00%	0.0%	0.56	2.10
Residential (general)	0.00	0.00%	0.0%	0.40	2.20
Commercial (general)	0.00	0.00%	0.0%	0.20	2.00
Industrial (general)	0.00	0.00%	0.0%	0.40	2.50
From CDM					
Agriculture and Pasture	0.00	0.00%	0.0%	0.37	5.98
Commercial	0.00	0.00%	0.0%	0.33	2.97
Forest/Rural Open	0.47	0.00%	0.0%	0.11	1.74
Highway	0.00	0.00%	0.0%	0.43	2.65
Industrial	0.00	0.00%	0.0%	0.32	3.97
Medium Density Residential	0.00	0.00%	0.0%	0.52	5.15
Urban Open	0.00	0.00%	0.0%	0.11	1.74
Water/Wetland	0.00	0.00%	0.0%	0.08	1.38
From Sheridan & Noske					
Gravel Road	0.00	100.00%	0.0%	0.55	1.40

Insert information for 8th sub-area below

Sub_Area_ID	**Miriam**	
Point of Analysis (PoA) Number	**4**	
Total Area for Sub-Area (acres)	**2.22**	**0.51**

Sub_Area_ID	**Miriam**		
Point of Analysis (PoA) Number	**4**		
Total Area in Sub-Area (acres)	**2.22**	**0.51**	**0.00**

Land Use	Area (acres)	Ia (% Impervious)
From HWG		
Residential Roof	0.15	100.00%
Commercial Roof	0.00	0.00%
Commercial/Res Parking	0.00	0.00%
Residential Street	0.00	100.00%
Urban Highway	0.00	0.00%
Lawns	0.36	0.00%
Driveway	0.14	0.00%
Residential (general)	0.00	0.00%
Commercial (general)	0.00	0.00%
Industrial (general)	0.00	0.00%
From CDM		
Agriculture and Pasture	0.00	0.00%
Commercial	0.00	0.00%
Forest/Rural Open	1.21	0.00%
Highway	0.00	0.00%
Industrial	0.00	0.00%
Medium Density Residential	0.00	0.00%
Urban Open	0.00	0.00%
Water/Wetland	0.00	0.00%
From Sheridan & Noske		

Land Use	Area (acres)	Ia (% Impervious)	Percent of Area that is managed turf (i.e., fertilized annually) %	Post-TP EMC mg/L	Post-TN EMC mg/L
From HWG					
Residential Roof	0.15	100.00%	0.0%	0.11	1.50
Commercial Roof	0.00	0.00%	0.0%	0.14	2.10
Commercial/Res Parking	0.00	0.00%	0.0%	0.15	1.90
Residential Street	0.36	100.00%	0.0%	0.55	1.40
Urban Highway	0.00	0.00%	0.0%	0.32	3.00
Lawns	0.36	0.00%	0.0%	2.10	9.10
Driveway	0.14	0.00%	0.0%	0.56	2.10
Residential (general)	0.00	0.00%	0.0%	0.40	2.20
Commercial (general)	0.00	0.00%	0.0%	0.20	2.00
Industrial (general)	0.00	0.00%	0.0%	0.40	2.50
From CDM					
Agriculture and Pasture	0.00	0.00%	0.0%	0.37	5.98
Commercial	0.00	0.00%	0.0%	0.33	2.97
Forest/Rural Open	1.21	0.00%	0.0%	0.11	1.74
Highway	0.00	0.00%	0.0%	0.43	2.65
Industrial	0.00	0.00%	0.0%	0.32	3.97
Medium Density Residential	0.00	0.00%	0.0%	0.52	5.15
Urban Open	0.00	0.00%	0.0%	0.11	1.74
Water/Wetland	0.00	0.00%	0.0%	0.08	1.38
From Sheridan & Noske					

Gravel Road	0.36	100.00%

Insert information for 9th sub-area below

Sub_Area_ID	**Rennie-N**	
Point of Analysis (PoA) Number	**2**	
Total Area for Sub-Area (acres)	**0.36**	**0.08**

Land Use	**Area** (acres)	**Ia** (% Impervious)
From HWG		
Residential Roof	0.03	100.00%
Commercial Roof	0.00	0.00%
Commercial/Res Parking	0.00	0.00%
Residential Street	0.00	100.00%
Urban Highway	0.00	0.00%
Lawns	0.06	0.00%
Driveway	0.00	0.00%
Residential (general)	0.00	0.00%
Commercial (general)	0.00	0.00%
Industrial (general)	0.00	0.00%
From CDM		
Agriculture and Pasture	0.00	0.00%
Commercial	0.00	0.00%
Forest/Rural Open	0.22	0.00%
Highway	0.00	0.00%
Industrial	0.00	0.00%
Medium Density Residential	0.00	0.00%
Urban Open	0.00	0.00%
Water/Wetland	0.00	0.00%
From Sheridan & Noske		
Gravel Road	0.05	100.00%

Insert information for 10th sub-area below

Sub_Area_ID	**Rennie-S**	
Point of Analysis (PoA) Number	**3**	
Total Area for Sub-Area (acres)	**1.49**	**0.22**

Land Use	**Area** (acres)	**Ia** (% Impervious)
From HWG		
Residential Roof	0.11	100.00%
Commercial Roof	0.00	0.00%
Commercial/Res Parking	0.00	0.00%
Residential Street	0.00	100.00%
Urban Highway	0.00	0.00%
Lawns	0.08	0.00%
Driveway	0.07	0.00%
Residential (general)	0.00	0.00%
Commercial (general)	0.00	0.00%
Industrial (general)	0.00	0.00%
From CDM		
Agriculture and Pasture	0.00	0.00%
Commercial	0.00	0.00%
Forest/Rural Open	1.12	0.00%

Gravel Road	0.00	100.00%	0.0%	0.55	1.40

Sub_Area_ID	**Rennie-N**				
Point of Analysis (PoA) Number	**2**				
Total Area in Sub-Area (acres)	**0.36**	**0.08**	**0.00**		

Land Use	**Area** (acres)	**Ia** (% Impervious)	**Percent of Area that is managed turf (i.e., fertilized annually)** %	**Post-TP EMC** mg/L	**Post-TN EMC** mg/L
From HWG					
Residential Roof	0.03	100.00%	0.0%	0.11	1.50
Commercial Roof	0.00	0.00%	0.0%	0.14	2.10
Commercial/Res Parking	0.00	0.00%	0.0%	0.15	1.90
Residential Street	0.06	100.00%	0.0%	0.55	1.40
Urban Highway	0.00	0.00%	0.0%	0.32	3.00
Lawns	0.06	0.00%	0.0%	2.10	9.10
Driveway	0.00	0.00%	0.0%	0.56	2.10
Residential (general)	0.00	0.00%	0.0%	0.40	2.20
Commercial (general)	0.00	0.00%	0.0%	0.20	2.00
Industrial (general)	0.00	0.00%	0.0%	0.40	2.50
From CDM					
Agriculture and Pasture	0.00	0.00%	0.0%	0.37	5.98
Commercial	0.00	0.00%	0.0%	0.33	2.97
Forest/Rural Open	0.21	0.00%	0.0%	0.11	1.74
Highway	0.00	0.00%	0.0%	0.43	2.65
Industrial	0.00	0.00%	0.0%	0.32	3.97
Medium Density Residential	0.00	0.00%	0.0%	0.52	5.15
Urban Open	0.00	0.00%	0.0%	0.11	1.74
Water/Wetland	0.00	0.00%	0.0%	0.08	1.38
From Sheridan & Noske					
Gravel Road	0.00	100.00%	0.0%	0.55	1.40

Sub_Area_ID	**Rennie-S**				
Point of Analysis (PoA) Number	**3**				
Total Area in Sub-Area (acres)	**1.49**	**0.22**	**0.00**		

Land Use	**Area** (acres)	**Ia** (% Impervious)	**Percent of Area that is managed turf (i.e., fertilized annually)** %	**Post-TP EMC** mg/L	**Post-TN EMC** mg/L
From HWG					
Residential Roof	0.11	100.00%	0.0%	0.11	1.50
Commercial Roof	0.00	0.00%	0.0%	0.14	2.10
Commercial/Res Parking	0.00	0.00%	0.0%	0.15	1.90
Residential Street	0.11	100.00%	0.0%	0.55	1.40
Urban Highway	0.00	0.00%	0.0%	0.32	3.00
Lawns	0.08	0.00%	0.0%	2.10	9.10
Driveway	0.06	0.00%	0.0%	0.56	2.10
Residential (general)	0.00	0.00%	0.0%	0.40	2.20
Commercial (general)	0.00	0.00%	0.0%	0.20	2.00
Industrial (general)	0.00	0.00%	0.0%	0.40	2.50
From CDM					
Agriculture and Pasture	0.00	0.00%	0.0%	0.37	5.98
Commercial	0.00	0.00%	0.0%	0.33	2.97
Forest/Rural Open	1.12	0.00%	0.0%	0.11	1.74

Land Use	Area	Ia
Highway	0.00	0.00%
Industrial	0.00	0.00%
Medium Density Residential	0.00	0.00%
Urban Open	0.00	0.00%
Water/Wetland	0.00	0.00%
From Sheridan & Noske		
Gravel Road	0.11	100.00%

Land Use	Area	Ia	%	mg/L	mg/L
Highway	0.00	0.00%	0.0%	0.43	2.65
Industrial	0.00	0.00%	0.0%	0.32	3.97
Medium Density Residential	0.00	0.00%	0.0%	0.52	5.15
Urban Open	0.00	0.00%	0.0%	0.11	1.74
Water/Wetland	0.00	0.00%	0.0%	0.08	1.38
From Sheridan & Noske					
Gravel Road	0.00	100.00%	0.0%	0.55	1.40

Insert information for 11th sub-area below

Sub_Area_ID	**Richards**	
Point of Analysis (PoA) Number	**3**	
Total Area for Sub-Area (acres)	**9.54**	**0.27**

Land Use	Area (acres)	Ia (% Impervious)
From HWG		
Residential Roof	0.17	100.00%
Commercial Roof	0.00	0.00%
Commercial/Res Parking	0.00	0.00%
Residential Street	0.00	100.00%
Urban Highway	0.00	0.00%
Lawns	0.53	0.00%
Driveway	0.31	0.00%
Residential (general)	0.00	0.00%
Commercial (general)	0.00	0.00%
Industrial (general)	0.00	0.00%
From CDM		
Agriculture and Pasture	0.00	0.00%
Commercial	0.00	0.00%
Forest/Rural Open	8.43	0.00%
Highway	0.00	0.00%
Industrial	0.00	0.00%
Medium Density Residential	0.00	0.00%
Urban Open	0.00	0.00%
Water/Wetland	0.00	0.00%
From Sheridan & Noske		
Gravel Road	0.10	100.00%

Sub_Area_ID	**Richards**		
Point of Analysis (PoA) Number	**3**		
Total Area in Sub-Area (acres)	**9.54**	**0.28**	**0.00**

Land Use	Area (acres)	Ia (% Impervious)	Percent of Area that is managed turf (i.e., fertilized annually) %	Post-TP EMC mg/L	Post-TN EMC mg/L
From HWG					
Residential Roof	0.17	100.00%	0.0%	0.11	1.50
Commercial Roof	0.00	0.00%	0.0%	0.14	2.10
Commercial/Res Parking	0.00	0.00%	0.0%	0.15	1.90
Residential Street	0.10	100.00%	0.0%	0.55	1.40
Urban Highway	0.00	0.00%	0.0%	0.32	3.00
Lawns	0.53	0.00%	0.0%	2.10	9.10
Driveway	0.31	0.00%	0.0%	0.56	2.10
Residential (general)	0.00	0.00%	0.0%	0.40	2.20
Commercial (general)	0.00	0.00%	0.0%	0.20	2.00
Industrial (general)	0.00	0.00%	0.0%	0.40	2.50
From CDM					
Agriculture and Pasture	0.00	0.00%	0.0%	0.37	5.98
Commercial	0.00	0.00%	0.0%	0.33	2.97
Forest/Rural Open	8.43	0.00%	0.0%	0.11	1.74
Highway	0.00	0.00%	0.0%	0.43	2.65
Industrial	0.00	0.00%	0.0%	0.32	3.97
Medium Density Residential	0.00	0.00%	0.0%	0.52	5.15
Urban Open	0.00	0.00%	0.0%	0.11	1.74
Water/Wetland	0.00	0.00%	0.0%	0.08	1.38
From Sheridan & Noske					
Gravel Road	0.00	100.00%	0.0%	0.55	1.40

Insert information for 12th sub-area below

Sub_Area_ID	**Shore**	
Point of Analysis (PoA) Number	**3**	
Total Area for Sub-Area (acres)	**6.28**	**1.06**

Land Use	Area (acres)	Ia (% Impervious)
From HWG		
Residential Roof	0.50	100.00%
Commercial Roof	0.00	0.00%
Commercial/Res Parking	0.00	0.00%
Residential Street	0.39	100.00%
Urban Highway	0.00	0.00%
Lawns	0.46	0.00%
Driveway	0.32	0.00%
Residential (general)	0.00	0.00%

Sub_Area_ID	**Shore**		
Point of Analysis (PoA) Number	**3**		
Total Area in Sub-Area (acres)	**6.28**	**1.12**	**0.00**

Land Use	Area (acres)	Ia (% Impervious)	Percent of Area that is managed turf (i.e., fertilized annually) %	Post-TP EMC mg/L	Post-TN EMC mg/L
From HWG					
Residential Roof	0.50	100.00%	0.0%	0.11	1.50
Commercial Roof	0.00	0.00%	0.0%	0.14	2.10
Commercial/Res Parking	0.00	0.00%	0.0%	0.15	1.90
Residential Street	0.58	100.00%	0.0%	0.55	1.40
Urban Highway	0.00	0.00%	0.0%	0.32	3.00
Lawns	0.45	0.00%	0.0%	2.10	9.10
Driveway	0.30	0.00%	0.0%	0.56	2.10
Residential (general)	0.00	0.00%	0.0%	0.40	2.20

Commercial (general)	0.00	0.00%	Commercial (general)	0.00	0.00%	0.0%	0.20	2.00
Industrial (general)	0.00	0.00%	Industrial (general)	0.00	0.00%	0.0%	0.40	2.50
From CDM			**From CDM**					
Agriculture and Pasture	0.00	0.00%	Agriculture and Pasture	0.00	0.00%	0.0%	0.37	5.98
Commercial	0.00	0.00%	Commercial	0.00	0.00%	0.0%	0.33	2.97
Forest/Rural Open	4.45	0.00%	Forest/Rural Open	4.40	0.00%	0.0%	0.11	1.74
Highway	0.00	0.00%	Highway	0.00	0.00%	0.0%	0.43	2.65
Industrial	0.00	0.00%	Industrial	0.00	0.00%	0.0%	0.32	3.97
Medium Density Residential	0.00	0.00%	Medium Density Residential	0.00	0.00%	0.0%	0.52	5.15
Urban Open	0.00	0.00%	Urban Open	0.00	0.00%	0.0%	0.11	1.74
Water/Wetland	0.00	0.00%	Water/Wetland	0.00	0.00%	0.0%	0.08	1.38
From Sheridan & Noske			**From Sheridan & Noske**					
Gravel Road	0.17	100.00%	Gravel Road	0.05	100.00%	0.0%	0.55	1.40

Insert information for 13th sub-area below

Sub_Area_ID	**Carter-W**		**Sub_Area_ID**	**Carter-W**				
Point of Analysis (PoA) Number	**2**		**Point of Analysis (PoA) Number**					
Total Area for Sub-Area (acres)	**1.35**	**0.38**	**Total Area in Sub-Area (acres)**	**1.35**	**0.41**	**0.00**		
						Percent of Area that is managed turf (i.e., fertilized annually)	**Post-TP EMC**	**Post-TN EMC**
Land Use	**Area**	**Ia**	**Land Use**	**Area**	**Ia**			
	(acres)	(% Impervious)		(acres)	(% Impervious)	%	mg/L	mg/L
From HWG			**From HWG**					
Residential Roof	0.17	100.00%	Residential Roof	0.17	100.00%	0.0%	0.11	1.50
Commercial Roof	0.00	0.00%	Commercial Roof	0.00	0.00%	0.0%	0.14	2.10
Commercial/Res Parking	0.00	0.00%	Commercial/Res Parking	0.00	0.00%	0.0%	0.15	1.90
Residential Street	0.18	100.00%	Residential Street	0.22	100.00%	0.0%	0.55	1.40
Urban Highway	0.00	0.00%	Urban Highway	0.00	0.00%	0.0%	0.32	3.00
Lawns	0.27	0.00%	Lawns	0.27	0.00%	0.0%	2.10	9.10
Driveway	0.14	0.00%	Driveway	0.13	0.00%	0.0%	0.56	2.10
Residential (general)	0.00	0.00%	Residential (general)	0.00	0.00%	0.0%	0.40	2.20
Commercial (general)	0.00	0.00%	Commercial (general)	0.00	0.00%	0.0%	0.20	2.00
Industrial (general)	0.00	0.00%	Industrial (general)	0.00	0.00%	0.0%	0.40	2.50
From CDM			**From CDM**					
Agriculture and Pasture	0.00	0.00%	Agriculture and Pasture	0.00	0.00%	0.0%	0.37	5.98
Commercial	0.00	0.00%	Commercial	0.00	0.00%	0.0%	0.33	2.97
Forest/Rural Open	0.56	0.00%	Forest/Rural Open	0.54	0.00%	0.0%	0.11	1.74
Highway	0.00	0.00%	Highway	0.00	0.00%	0.0%	0.43	2.65
Industrial	0.00	0.00%	Industrial	0.00	0.00%	0.0%	0.32	3.97
Medium Density Residential	0.00	0.00%	Medium Density Residential	0.00	0.00%	0.0%	0.52	5.15
Urban Open	0.00	0.00%	Urban Open	0.00	0.00%	0.0%	0.11	1.74
Water/Wetland	0.00	0.00%	Water/Wetland	0.00	0.00%	0.0%	0.08	1.38
From Sheridan & Noske			**From Sheridan & Noske**					
Gravel Road	0.03	100.00%	Gravel Road	0.02	100.00%	0.0%	0.55	1.40

EVENT MEAN CONCENTRATIONS (EMC OR C)

Land Use	TSS	Pre - TP	Pre - TN
	mg/L	mg/L	mg/L
From HWG			
Residential Roof	19	0.11	1.50
Commercial Roof	9	0.14	2.10
Commercial/Res Parking	27	0.15	1.90
Residential Street	172	0.55	1.40
Urban Highway	142	0.32	3.00
Lawns	80	2.10	9.10
Driveways	173	0.56	2.10
Residential (general)	100	0.40	2.20
Commercial (general)	75	0.20	2.00
Industrial (general)	120	0.40	2.50
From CDM			
Agriculture and Pasture	145	0.37	5.98
Commercial	77	0.33	2.97
Forest/Rural Open	51	0.11	1.74
Highway	141	0.43	2.65
Industrial	149	0.32	3.97
Medium Density Residential	70	0.52	5.15
Urban Open	51	0.11	1.74
Water/Wetland	6	0.08	1.38
From Sheridan & Noske (2007)*			
Gravel Road (2WD, light trucks)	496	0.55	1.40

*TSS Loading adopted from Sheridan & Noske; TN & TP washoff assumed to match paved residential roads.

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ONLY CHANGE VALUES SHADED IN BLUE

PRE DEVELOPMENT

Sub-Area	INPUT BMP DESCRIPTIONS		TSS	TP	TN
Arnold					
Carter-E					
Lake-N					
Lake-S					
Longa					
Mayhew-E					
Mayhew-W					
Miriam					
Rennie-N					
Rennie-S					
Richards					
Shore					
Carter-W					

INPUT OVERALL REMOVAL EFFICIENCIES (%) FOR POLLUTANTS OF CONCERN

POST DEVELOPMENT

Sub-Area	INPUT BMP DESCRIPTIONS		TSS	TP	TN
Arnold	None proposed		0%	0%	0%
Carter-E	Area served by tree boxes		86%	34%	70%
Lake-N	None proposed		0%	0%	0%
Lake-S	None proposed		0%	0%	0%
Longa	Entire area served by treatment swale		81%	38%	9%
Mayhew-E	Entire area served by stormwater wetland		80%	55%	45%
Mayhew-W	Entire area served by tree box		86%	34%	70%
Miriam	Served in series by bioretention and stormwater wetland; highest removals (bioretention) were used		90%	65%	65%
Rennie-N	Entire area served by tree box		86%	34%	70%
Rennie-S	Entire Area served by tree box		86%	34%	70%
Richards	None proposed		0%	0%	0%
Shore	50% served by tree boxes/ bioretention (40% at outfall, 10% at Richards)		43%	17%	35%
Carter-W	Area served by hydrodynamic separator		80%	0%	0%

INPUT OVERALL REMOVAL EFFICIENCIES (%) FOR POLLUTANTS OF CONCERN

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TOTAL PRE -DEVELOPMENT (PRE-DEV) AREA (ACRES) =	57.01
TOTAL PRE-DEV EFFECTIVE IMPERVIOUS AREA (ACRES) =	7.25
TOTAL PRE-DEV PERCENT EFFECTIVE IMPERVIOUS (%) =	12.7%
TOTAL POST DEVELOPMENT (POST-DEV) AREA (ACRES) =	57.01
TOTAL POST-DEV EFFECTIVE IMPERVIOUS AREA (ACRES) =	7.74
TOTAL POST-DEV PERCENT EFFECTIVE IMPERVIOUS (%) =	13.6%
TOTAL POST-DEV AREA THAT IS FERTILIZED ANNUALLY (ACRES) =	0.00
TOTAL POST-DEV PERCENT OF AREA THAT IS FERTILIZED ANNUALLY (%) =	0.0%

	TSS (LBS/YR)	TP (LBS/YR)	TN (LBS/YR)
PRE DEVELOPMENT LOADS (NO BMPS)	12489.5	25.9	141.0
PRE DEVELOPMENT LOADS (WITH BMPS)	12489.5	25.9	141.0
PRE DEVELOPMENT LOAD REDUCTION DUE TO BMPS	0.0	0.0	0.0
PROPOSED PERCENT REDUCTION IN FERTILIZER APPLICATION RATE	NA	0.0%	0.0%
POST DEVELOPMENT LOADS (NO BMPS)	7937.8	28.0	146.1
POST DEVELOPMENT LOADS (WITH BMPS)	4618.1	22.7	115.7
POST DEVELOPMENT LOAD REDUCTION DUE TO BMPS	3319.7	5.3	30.5
POST DEVELOPMENT - PRE DEVELOPMENT (SHOULD BE 0 OR NEGATIVE)	-7871.4	-3.2	-25.4
% DIFFERENCE FROM PRE DEVELOMENT LOADS (SHOULD BE 0 OR NEGATIVE)	-63.0%	-12.3%	-18.0%
TOTAL REMOVAL EFFICIENCY NEEDED TO MEET PRE-DEVELOPMENT LOAD	-57.3%	7.6%	3.5%

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TOTAL POST DEVELOPMENT - PRE DEVELOPMENT (SHOULD BE 0 OR NEGATIVE) (lbs/yr)	-3.2
% DIFFERENCE FROM PRE DEVELOMENT LOADS (SHOULD BE 0 OR NEGATIVE)	-12.3%
TOTAL REMOVAL EFFICIENCY NEEDED TO MEET PRE-DEVELOPMENT LOAD	7.6%
CURRENTLY PROPOSED REMOVAL EFFICIENCY	19.0%
REMAINING REMOVAL EFFICIENCY NECESSARY TO MEET PRE-DEVELOPMENT LOAD	-11.4%

PRE-DEVELOPMENT

PRE OR POST - DEV	SUB-AREA	POINT OF ANALYSIS NUMBER	AREA (acres)	Effective Impervious Area (acres)	Area Fertilized Annually (acres)	POLLUTANT	PERCENT REDUCTION IN FERTILIZER APPLICATION RATE	BMPS	LOAD (NO BMPS) (lbs/yr)	LOAD (WITH BMPS) (lbs/yr)	LOAD REDUCTION DUE TO BMPS (lbs/yr)	PERCENT REMOVAL
PRE	Arnold	2	2.57	0.30	NA	TP	NA		0.9	0.9	0.0	0.0%
PRE	Carter-E	2	3.69	0.70	NA	TP	NA		2.6	2.6	0.0	0.0%
PRE	Lake-N	1	12.27	1.47	NA	TP	NA		4.3	4.3	0.0	0.0%
PRE	Lake-S	4	11.20	1.29	NA	TP	NA		3.7	3.7	0.0	0.0%
PRE	Longa	3	3.67	0.56	NA	TP	NA		2.4	2.4	0.0	0.0%
PRE	Mayhew-E	3	1.72	0.28	NA	TP	NA		1.3	1.3	0.0	0.0%
PRE	Mayhew-W	3	0.65	0.14	NA	TP	NA		0.6	0.6	0.0	0.0%
PRE	Miriam	4	2.22	0.51	NA	TP	NA		2.2	2.2	0.0	0.0%
PRE	Rennie-N	2	0.36	0.08	NA	TP	NA		0.3	0.3	0.0	0.0%
PRE	Rennie-S	3	1.49	0.22	NA	TP	NA		0.8	0.8	0.0	0.0%
PRE	Richards	3	9.54	0.27	NA	TP	NA		1.6	1.6	0.0	0.0%
PRE	Shore	3	6.28	1.06	NA	TP	NA		3.7	3.7	0.0	0.0%
PRE	Carter-W	2	1.35	0.38	NA	TP	NA		1.4	1.4	0.0	0.0%
		TOTAL	57.01	7.25				TOTAL	25.9	25.9	0.0	0.0%

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POST-DEVELOPMENT

PRE OR POST - DEV	SUB-AREA	POINT OF ANALYSIS NUMBER	AREA (acres)	Effective Impervious Area (acres)	Area Fertilized Annually (acres)	POLLUTANT	PERCENT REDUCTION IN FERTILIZER APPLICATION RATE	BMPS	LOAD (NO BMPS) (lbs/yr)	LOAD (WITH BMPS) (lbs/yr)	LOAD REDUCTION DUE TO BMPS (lbs/yr)	PERCENT REMOVAL
POST	Arnold	2	2.57	0.31	0.00	TP	0.0%	None proposed	1.0	1.0	0.0	0.0%
POST	Carter-E	2	3.69	0.81	0.00	TP	0.0%	Area served by tree boxes	3.0	2.0	1.0	34.0%
POST	Lake-N	1	12.27	1.57	0.00	TP	0.0%	None proposed	4.8	4.8	0.0	0.0%
POST	Lake-S	4	11.20	1.47	0.00	TP	0.0%	None proposed	4.5	4.5	0.0	0.0%
POST	Longa	3	3.67	0.52	0.00	TP	0.0%	Entire area served by treatment swale	2.2	1.3	0.8	38.0%
POST	Mayhew-E	3	1.72	0.28	0.00	TP	0.0%	Entire area served by stormwater wetland	1.3	0.6	0.7	55.0%
POST	Mayhew-W	3	0.65	0.15	0.00	TP	0.0%	Entire area served by tree box	0.7	0.4	0.2	34.0%
POST	Miriam	4	2.22	0.51	0.00	TP	0.0%	Served in series by bioretention and stormwater wetland; highest removals (bioretention) were used	2.2	0.8	1.5	65.0%
POST	Rennie-N	2	0.36	0.08	0.00	TP	0.0%	Entire area served by tree box	0.4	0.2	0.1	34.0%
POST	Rennie-S	3	1.49	0.22	0.00	TP	0.0%	Entire Area served by tree box	0.8	0.5	0.3	34.0%
POST	Richards	3	9.54	0.28	0.00	TP	0.0%	None proposed	1.6	1.6	0.0	0.0%
POST	Shore	3	6.28	1.12	0.00	TP	0.0%	50% served by tree boxes/ bioretention (40% at outfall, 10% at Richards)	4.0	3.3	0.7	17.0%
POST	Carter-W	2	1.35	0.41	0.00	TP	0.0%	Area served by hydrodynamic separator	1.6	1.6	0.0	0.0%
		TOTAL	57.01	7.74	0.00			TOTAL	28.0	22.7	5.3	19.0%

Breakdown by Project	
Reductions based on Roadway Paving:	-2.1
Reductions from Tree Boxes:	2.2
Reductions from Hydrodynamic Separator:	0.0
Reductions from Vegetated Swale:	0.8
Reductions from Richards Bioretention:	0.13720151
Reductions from Mayhew Wetland:	0.7
Reductions from Miriam Park:	1.5

Breakdown by Phase	
Phase 1	0.5
Phase 2A	0.9
Phase 2B	2.2
Phase 3	-0.4

Date (MM/DD/YYYY): 7/15/2022
Project Name: Pike Knoll Shores Drainage Study
Town/City: Merrimack, NH
Impacted Surface Waters: Baboosic Lake
Applicant:
DES File #:

TOTAL POST DEVELOPMENT - PRE DEVELOPMENT (SHOULD BE 0 OR NEGATIVE) (lbs/yr)	-25.4
% DIFFERENCE FROM PRE DEVELOMENT LOADS (SHOULD BE 0 OR NEGATIVE)	-18.0%
TOTAL REMOVAL EFFICIENCY NEEDED TO MEET PRE-DEVELOPMENT LOAD	3.5%
CURRENTLY PROPOSED REMOVAL EFFICIENCY	20.8%
REMAINING REMOVAL EFFICIENCY NECESSARY TO MEET PRE-DEVELOPMENT LOAD	-17.4%

PRE-DEVELOPMENT

PRE OR POST - DEV	SUB-AREA	POINT OF ANALYSIS NUMBER	AREA (acres)	Effective Impervious Area (acres)	Area Fertilized Annually (acres)	POLLUTANT	PERCENT REDUCTION IN FERTILIZER APPLICATION RATE	BMPS	LOAD (NO BMPS) (lbs/yr)	LOAD (WITH BMPS) (lbs/yr)	LOAD REDUCTION DUE TO BMPS (lbs/yr)	PERCENT REMOVAL
PRE	Arnold	2	2.57	0.30	NA	TN	NA		6.3	6.3	0.0	0.0%
PRE	Carter-E	2	3.69	0.70	NA	TN	NA		12.6	12.6	0.0	0.0%
PRE	Lake-N	1	12.27	1.47	NA	TN	NA		28.6	28.6	0.0	0.0%
PRE	Lake-S	4	11.20	1.29	NA	TN	NA		25.2	25.2	0.0	0.0%
PRE	Longa	3	3.67	0.56	NA	TN	NA		10.2	10.2	0.0	0.0%
PRE	Mayhew-E	3	1.72	0.28	NA	TN	NA		5.4	5.4	0.0	0.0%
PRE	Mayhew-W	3	0.65	0.14	NA	TN	NA		2.0	2.0	0.0	0.0%
PRE	Miriam	4	2.22	0.51	NA	TN	NA		8.6	8.6	0.0	0.0%
PRE	Rennie-N	2	0.36	0.08	NA	TN	NA		1.4	1.4	0.0	0.0%
PRE	Rennie-S	3	1.49	0.22	NA	TN	NA		3.9	3.9	0.0	0.0%
PRE	Richards	3	9.54	0.27	NA	TN	NA		12.2	12.2	0.0	0.0%
PRE	Shore	3	6.28	1.06	NA	TN	NA		18.3	18.3	0.0	0.0%
PRE	Carter-W	2	1.35	0.38	NA	TN	NA		6.3	6.3	0.0	0.0%
		TOTAL	57.01	7.25				TOTAL	141.0	141.0	0.0	0.0%

Date (MM/DD/YYYY): 7/15/2022
Project Name: Pike Knoll Shores Drainage Study
Town/City: Merrimack, NH
Impacted Surface Waters: Baboosic Lake
Applicant:
DES File #:

POST-DEVELOPMENT

PRE OR POST - DEV	SUB-AREA	POINT OF ANALYSIS NUMBER	AREA (acres)	Effective Impervious Area (acres)	Area Fertilized Annually (acres)	POLLUTANT	PERCENT REDUCTION IN FERTILIZER APPLICATION RATE	BMPS	LOAD (NO BMPS) (lbs/yr)	LOAD (WITH BMPS) (lbs/yr)	LOAD REDUCTION DUE TO BMPS (lbs/yr)	PERCENT REMOVAL
POST	Arnold	2	2.57	0.31	0.00	TN	0.0%	None proposed	6.4	6.4	0.0	0.0%
POST	Carter-E	2	3.69	0.81	0.00	TN	0.0%	Area served by tree boxes	13.7	4.1	9.6	70.0%
POST	Lake-N	1	12.27	1.57	0.00	TN	0.0%	None proposed	29.7	29.7	0.0	0.0%
POST	Lake-S	4	11.20	1.47	0.00	TN	0.0%	None proposed	27.2	27.2	0.0	0.0%
POST	Longa	3	3.67	0.52	0.00	TN	0.0%	Entire area served by treatment swale	9.6	8.7	0.9	9.0%
POST	Mayhew-E	3	1.72	0.28	0.00	TN	0.0%	Entire area served by stormwater wetland	5.4	3.0	2.4	45.0%
POST	Mayhew-W	3	0.65	0.15	0.00	TN	0.0%	Entire area served by tree box	2.2	0.7	1.5	70.0%
POST	Miriam	4	2.22	0.51	0.00	TN	0.0%	Served in series by bioretention and stormwater wetland; highest removals (bioretention) were used	8.6	3.0	5.6	65.0%
POST	Rennie-N	2	0.36	0.08	0.00	TN	0.0%	Entire area served by tree box	1.4	0.4	1.0	70.0%
POST	Rennie-S	3	1.49	0.22	0.00	TN	0.0%	Entire Area served by tree box	3.9	1.2	2.8	70.0%
POST	Richards	3	9.54	0.28	0.00	TN	0.0%	None proposed	12.3	12.3	0.0	0.0%
POST	Shore	3	6.28	1.12	0.00	TN	0.0%	50% served by tree boxes/ bioretention (40% at outfall, 10% at Richards)	19.1	12.4	6.7	35.0%
POST	Carter-W	2	1.35	0.41	0.00	TN	0.0%	Area served by hydrodynamic separator	6.6	6.6	0.0	0.0%
		TOTAL	57.01	7.74	0.00			TOTAL	146.1	115.7	30.5	20.8%

Breakdown by Project	
Reductions based on Roadway Paving:	-5.1
Reductions from Tree Boxes:	20.2
Reductions from Hydrodynamic Separator:	0.0
Reductions from Vegetated Swale:	0.9
Reductions from Richards Bioretention:	1.335160672
Reductions from Mayhew Wetland:	2.4
Reductions from Miriam Park:	5.6

Breakdown by Phase	
Phase 1	9.0
Phase 2A	4.4
Phase 2B	8.0
Phase 3	4.0

Date (MM/DD/YYYY): 7/15/2022
Project Name: Pike Knoll Shores Drainage Study
Town/City: Merrimack, NH
Impacted Surface Waters: Baboosic Lake
Applicant:
DES File #:

TOTAL POST DEVELOPMENT - PRE DEVELOPMENT (SHOULD BE 0 OR NEGATIVE) (lbs/yr)	-7871.4
% DIFFERENCE FROM PRE DEVELOMENT LOADS (SHOULD BE 0 OR NEGATIVE)	-63.0%
TOTAL REMOVAL EFFICIENCY NEEDED TO MEET PRE-DEVELOPMENT LOAD	-57.3%
CURRENTLY PROPOSED REMOVAL EFFICIENCY	41.8%
REMAINING REMOVAL EFFICIENCY NECESSARY TO MEET PRE-DEVELOPMENT LOAD	-99.2%

PRE-DEVELOPMENT

PRE OR POST - DEV	SUB-AREA	POINT OF ANALYSIS NUMBER	AREA (acres)	Effective Impervious Area (acres)	Area Fertilized Annually (acres)	POLLUTANT	PERCENT REDUCTION IN FERTILIZER APPLICATION RATE	BMPS	LOAD (NO BMPS) (lbs/yr)	LOAD (WITH BMPS) (lbs/yr)	LOAD REDUCTION DUE TO BMPS (lbs/yr)	PERCENT REMOVAL
PRE	Arnold	2	2.57	0.30	NA	TSS	NA		397.2	397.2	0.0	0.0%
PRE	Carter-E	2	3.69	0.70	NA	TSS	NA		650.5	650.5	0.0	0.0%
PRE	Lake-N	1	12.27	1.47	NA	TSS	NA		2063.6	2063.6	0.0	0.0%
PRE	Lake-S	4	11.20	1.29	NA	TSS	NA		1380.8	1380.8	0.0	0.0%
PRE	Longa	3	3.67	0.56	NA	TSS	NA		1700.9	1700.9	0.0	0.0%
PRE	Mayhew-E	3	1.72	0.28	NA	TSS	NA		840.9	840.9	0.0	0.0%
PRE	Mayhew-W	3	0.65	0.14	NA	TSS	NA		536.4	536.4	0.0	0.0%
PRE	Miriam	4	2.22	0.51	NA	TSS	NA		1579.4	1579.4	0.0	0.0%
PRE	Rennie-N	2	0.36	0.08	NA	TSS	NA		223.8	223.8	0.0	0.0%
PRE	Rennie-S	3	1.49	0.22	NA	TSS	NA		527.9	527.9	0.0	0.0%
PRE	Richards	3	9.54	0.27	NA	TSS	NA		678.8	678.8	0.0	0.0%
PRE	Shore	3	6.28	1.06	NA	TSS	NA		1469.5	1469.5	0.0	0.0%
PRE	Carter-W	2	1.35	0.38	NA	TSS	NA		440.1	440.1	0.0	0.0%
		TOTAL	57.01	7.25				TOTAL	12489.5	12489.5	0.0	0.0%

Date (MM/DD/YYYY): 7/15/2022
Project Name: Pike Knoll Shores Drainage Study
Town/City: Merrimack, NH
Impacted Surface Waters: Baboosic Lake
Applicant:
DES File #:

TOTAL POST DEVELOPMENT - PRE DEVELOPMENT (SHOULD BE 0 OR NEGATIVE) (lbs/yr)	-7871.4
% DIFFERENCE FROM PRE DEVELOMENT LOADS (SHOULD BE 0 OR NEGATIVE)	-63.0%
TOTAL REMOVAL EFFICIENCY NEEDED TO MEET PRE-DEVELOPMENT LOAD	-57.3%
CURRENTLY PROPOSED REMOVAL EFFICIENCY	41.8%
REMAINING REMOVAL EFFICIENCY NECESSARY TO MEET PRE-DEVELOPMENT LOAD	-99.2%

POST-DEVELOPMENT

PRE OR POST - DEV	SUB-AREA	POINT OF ANALYSIS NUMBER	AREA (acres)	Effective Impervious Area (acres)	Area Fertilized Annually (acres)	POLLUTANT	PERCENT REDUCTION IN FERTILIZER APPLICATION RATE	BMPS	LOAD (NO BMPS) (lbs/yr)	LOAD (WITH BMPS) (lbs/yr)	LOAD REDUCTION DUE TO BMPS (lbs/yr)	PERCENT REMOVAL
POST	Arnold	2	2.57	0.31	0.00	TSS	NA	None proposed	217.0	217.0	0.0	0.0%
POST	Carter-E	2	3.69	0.81	0.00	TSS	NA	Area served by tree boxes	788.1	110.3	677.8	86.0%
POST	Lake-N	1	12.27	1.57	0.00	TSS	NA	None proposed	1529.7	1529.7	0.0	0.0%
POST	Lake-S	4	11.20	1.47	0.00	TSS	NA	None proposed	1239.7	1239.7	0.0	0.0%
POST	Longa	3	3.67	0.52	0.00	TSS	NA	Entire area served by treatment swale	600.4	114.1	486.3	81.0%
POST	Mayhew-E	3	1.72	0.28	0.00	TSS	NA	Entire area served by stormwater wetland	329.9	66.0	263.9	80.0%
POST	Mayhew-W	3	0.65	0.15	0.00	TSS	NA	Entire area served by tree box	212.7	29.8	182.9	86.0%
POST	Miriam	4	2.22	0.51	0.00	TSS	NA	Served in series by bioretention and stormwater wetland; highest removals (bioretention) were used	598.6	59.9	538.8	90.0%
POST	Rennie-N	2	0.36	0.08	0.00	TSS	NA	Entire area served by tree box	92.1	12.9	79.2	86.0%
POST	Rennie-S	3	1.49	0.22	0.00	TSS	NA	Entire Area served by tree box	215.2	30.1	185.0	86.0%
POST	Richards	3	9.54	0.28	0.00	TSS	NA	None proposed	409.7	409.7	0.0	0.0%
POST	Shore	3	6.28	1.12	0.00	TSS	NA	50% served by tree boxes/ bioretention (40% at outfall, 10% at Richards)	1237.8	705.5	532.2	43.0%
		TOTAL	57.01	7.74	0.00			TOTAL	7937.8	4618.1	3319.7	41.8%

Breakdown by Project	
Reductions based on Roadway Paving:	4552
Reductions from Tree Boxes:	1551
Reductions from Hydrodynamic Separator:	373
Reductions from Vegetated Swale:	486
Reductions from Richards Bioretention:	106
Reductions from Mayhew Wetland:	264
Reductions from Miriam Park:	539

Breakdown by Phase	
Phase 1	1097.7
Phase 2A	2233.6
Phase 2B	3366.0
Phase 3	905.0

Appendix E – Subdivision Traffic Analysis & Recommendations

AECOM

AECOM
250 Apollo Drive
Chelmsford, MA 01824
aecom.com

Project name:
Baboosic Lake - Pine Knoll Shores Drainage Study

Project ref:
60680349

To:
File

CC:

From:
Arianna Seguin, PE &
Glenn Stevens, PE

Date:
September 28, 2022

DRAFT

Memorandum

Subject: Pine Knoll Shores Subdivison Traffic Assessment & Recommendations

As part of the Baboosic Lake - Pine Knoll Shores Subdivision Drainage Study located in Merrimack, New Hampshire, , AECOM has proposed roadway pavement and drainage improvements to reduce sediment and nutrient loading to the Lake. To support this recommendation, AECOM investigated the traffic flow of the various local roadways within the development off of Baboosic Lake Road to support signage and directionality recommendations. When performing the traffic evaluation, AECOM considered two major components during the review to improve vehicular and pedestrian safety. The first consideration was reviewing the existing roadway widths within the town right-of-way and evaluate the potential of one-way traffic flow within the development. The second consideration was reviewing the horizontal sight distances for visual clearance from the local roadway to Baboosic Lake Road.

As shown in **Figure E-1,** AECOM in conjunction with the Town of Merrimack DPW have proposed to maintain the existing two-way traffic flow on Carter Avenue, Shore Drive, Thomas Road, and Donald Road with a 24-foot paved cross section. In addition, the recommendations also included converting existing two-way roadways to 16-foot one-way roadways on the following roadways:

- Miriam Road
- Arnold Road
- Mayhew Road
- Longa Road
- Rennie Road
- Richards Road

The directionality of these roadways was determined not only by using the existing roadway width configurations, but also the horizontal sight distances for the roadways intersecting with Baboosic Lake Road. Merrimack DPW and Engineering Department officials provided horizontal sight distances which AECOM reviewed, verified, and summarized in **Table E-1**.

Table E-1. Baboosic Lake Road Horizontal Sight Distance

Intersecting Roadway	Sight Distance to North (feet)	Sight Distance to South (feet)
Longa Road	475	600
Mayhew Road	67*	600
Carter Road	157	261
Miriam Road	222	259
Thomas Road	324	244

* Large Oak Tree in northwest quadrant

Source: Merrimack DPW and Engineering Department

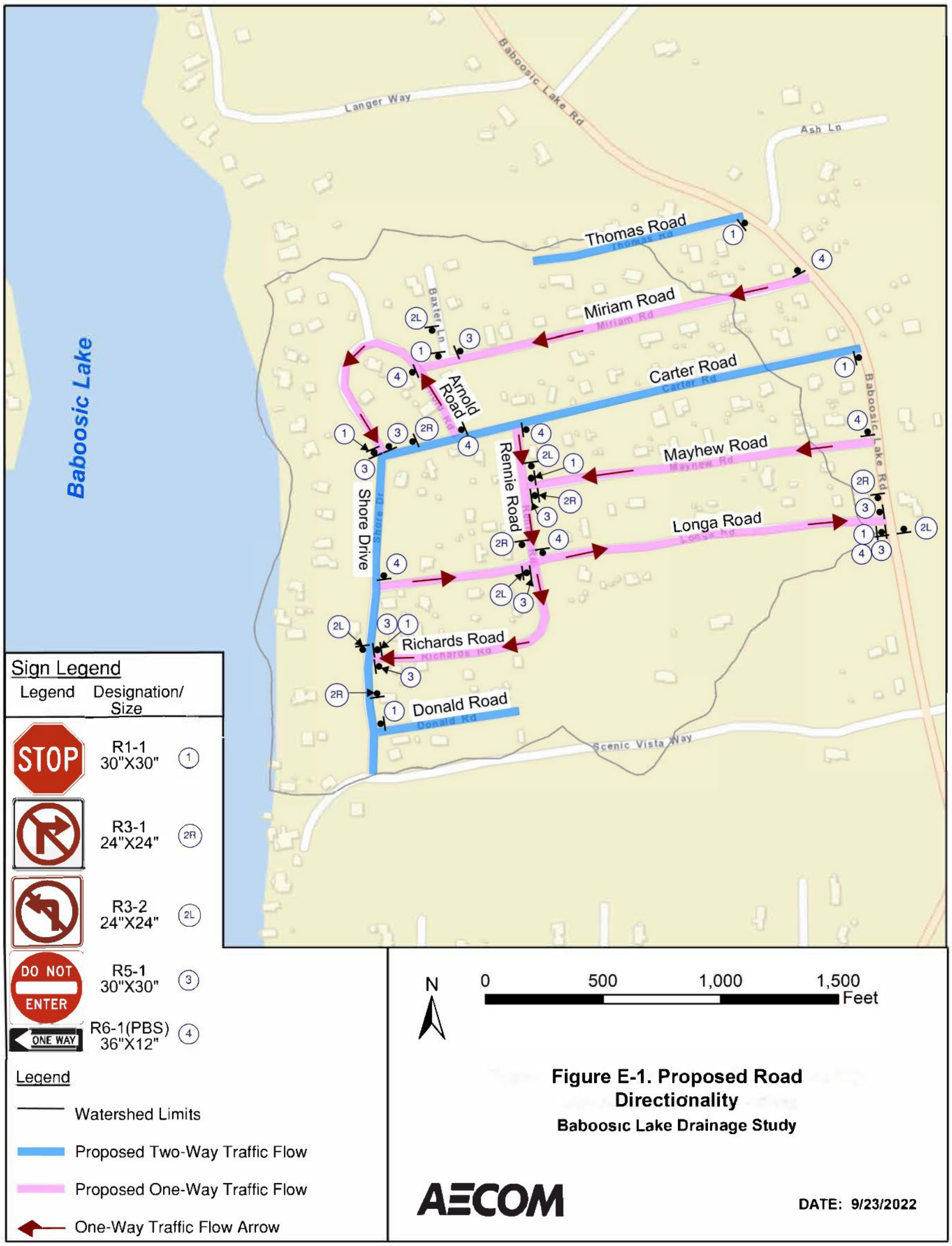


Figure E-1 Proposed Road Directionality and Signage

Using the existing roadway widths and horizontal sight distances, the following roadway directionalities were determined as listed below:

Table E-2. Subdivision Roadway Traffic Flow

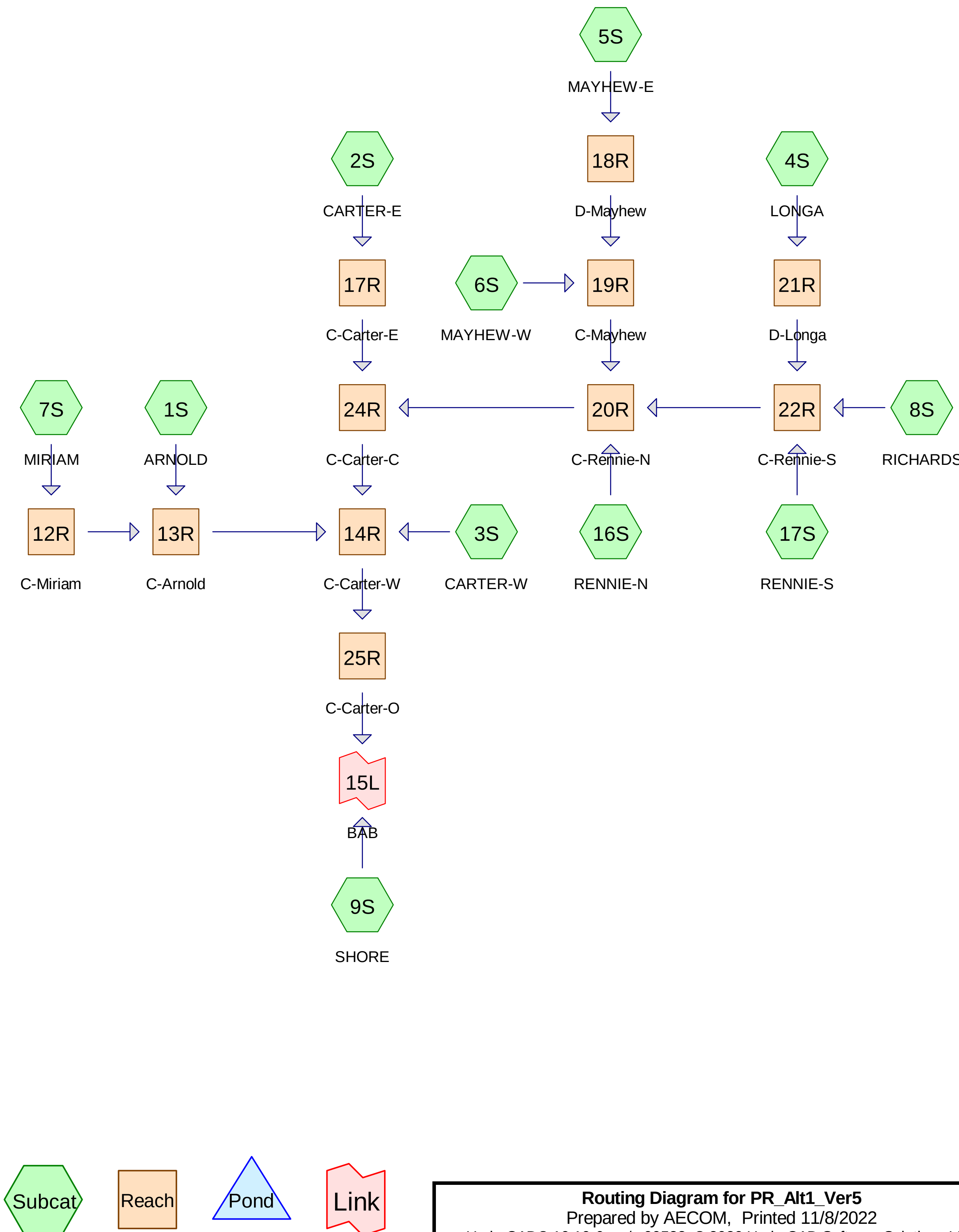
Roadway	Traffic Flow Direction	Justifications
Miriam Road	Traffic flowing west from Baboosic Lake Rd toward the lake	Reduced sight distance Roadway width < 30 feet
Arnold Road	Traffic flowing north from Carter Rd to the west at Shore Drive intersection	Roadway width < 20 feet
Mayhew Road	Traffic flowing west from Baboosic Lake Rd toward the lake	Reduced sight distance Roadway width < 30 feet
Longa Road	Traffic flowing east towards Baboosic Lake Rd from the lake	Best sight distance at Baboosic Lake Rd Roadway width < 20-30 feet
Rennie Road	Traffic Flowing south from Carter Rd towards Richards Rd	Roadway width < 25 feet
Richards Road	Traffic flowing west from Rennie Rd towards Shore Dr	Roadway width < 20 feet

The recommendation for Miriam Road and Mayhew Road to be modified to one-way west traffic flow was due to reduced sight distance at the intersections with Baboosic Lake Road when compared with other adjacent streets in the development whereas Longa Road is proposed with one-way easterly traffic flow with the best sight distance. All other roadway directionalities listed in **Table E-2** are proposed based on the overall circulation of traffic within the subdivision.
Lastly, AECOM has included additional recommended signage shown on **Figure E-1** in conjunction with the proposed roadway widths and new recommended directionalities. All proposed signs are in compliance with the latest edition of the Manual on Uniform Traffic Control Devices (MUTCD) improving traffic flow and roadway safety.

Appendix F – Hydraulics Analysis

F-1. HydroCAD Model Files & Documentation

F-2. Manning's Capacity Calculation



Routing Diagram for PR_Alt1_Ver5
Prepared by AECOM, Printed 11/8/2022
HydroCAD® 10.10-6a s/n 00538 © 2020 HydroCAD Software Solutions LLC

Rainfall Events Listing (selected events)

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	25-yr+15%	NRCC_Merr 24-hr S1	25-yr	Default	24.00	1	6.28	2

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
1.905	98	(3S, 9S)
3.117	69	50-75% Grass cover, Fair, HSG B (lawn) (1S, 2S, 3S, 4S, 5S, 7S, 8S, 9S, 16S, 17S)
0.173	98	Bldg (8S)
0.373	98	Building (5S, 7S, 16S, 17S)
0.776	98	Buildings (1S, 2S, 4S, 6S)
0.261	98	Driveway (2S)
0.068	85	Gravel roads, HSG B (3S, 9S)
0.487	98	Paved Driveway (1S, 5S, 6S, 7S, 17S)
0.429	98	Paved Driveways (4S, 8S)
0.442	98	Paved Rd (5S, 6S, 17S)
0.951	98	Paved Road (1S, 2S, 7S, 16S)
0.446	98	Paved Roads (4S, 8S)
23.087	58	Woods/grass comb., Good, HSG B (open area) (1S, 2S, 3S, 4S, 6S, 7S, 8S, 9S, 16S, 17S)
1.028	58	Woods/grass comb., Good, HSG B (open) (5S)
33.543	**67**	**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	0.000	0.000	0.000	1.905	1.905		3S, 9S
0.000	3.117	0.000	0.000	0.000	3.117	50-75% Grass cover, Fair	1S, 2S, 3S, 4S, 5S, 7S, 8S, 9S, 16S, 17S
0.000	0.000	0.000	0.000	0.173	0.173	Bldg	8S
0.000	0.000	0.000	0.000	0.373	0.373	Building	5S, 7S, 16S, 17S
0.000	0.000	0.000	0.000	0.776	0.776	Buildings	1S, 2S, 4S, 6S
0.000	0.000	0.000	0.000	0.261	0.261	Driveway	2S
0.000	0.068	0.000	0.000	0.000	0.068	Gravel roads	3S, 9S
0.000	0.000	0.000	0.000	0.487	0.487	Paved Driveway	1S, 5S, 6S, 7S, 17S
0.000	0.000	0.000	0.000	0.429	0.429	Paved Driveways	4S, 8S
0.000	0.000	0.000	0.000	0.442	0.442	Paved Rd	5S, 6S, 17S
0.000	0.000	0.000	0.000	0.951	0.951	Paved Road	1S, 2S, 7S, 16S
0.000	0.000	0.000	0.000	0.446	0.446	Paved Roads	4S, 8S
0.000	24.115	0.000	0.000	0.000	24.115	Woods/grass comb., Good	1S, 2S, 3S, 4S, 5S, 6S, 7S, 8S, 9S, 16S, 17S
0.000	**27.300**	**0.000**	**0.000**	**6.243**	**33.543**	**TOTAL AREA**	

Pipe Listing (all nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Width (inches)	Diam/Height (inches)	Inside-Fill (inches)
1	1S	0.00	0.00	15.0	0.0275	0.025	0.0	12.0	0.0
2	12R	321.30	285.10	845.0	0.0428	0.009	0.0	12.0	0.0
3	13R	285.10	283.86	225.0	0.0055	0.009	0.0	18.0	0.0
4	14R	283.86	272.77	260.0	0.0427	0.009	0.0	24.0	0.0
5	17R	326.80	289.80	640.0	0.0578	0.009	0.0	12.0	0.0
6	19R	323.00	294.50	450.0	0.0633	0.009	0.0	12.0	0.0
7	20R	294.50	289.80	190.0	0.0247	0.009	0.0	24.0	0.0
8	22R	297.80	294.50	235.0	0.0140	0.012	0.0	24.0	0.0
9	24R	289.80	283.86	150.0	0.0396	0.009	0.0	24.0	0.0
10	25R	272.77	250.80	210.0	0.1046	0.009	0.0	24.0	0.0

Time span=0.00-40.00 hrs, dt=0.05 hrs, 801 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: ARNOLD Runoff Area=2.570 ac 17.32% Impervious Runoff Depth=2.65"
Flow Length=747' Tc=24.8 min CN=66 Runoff=4.16 cfs 0.567 af

Subcatchment 2S: CARTER-E Runoff Area=3.694 ac 28.88% Impervious Runoff Depth=3.13"
Flow Length=646' Tc=22.3 min CN=71 Runoff=7.55 cfs 0.962 af

Subcatchment 3S: CARTER-W Runoff Area=1.354 ac 38.63% Impervious Runoff Depth=3.62"
Flow Length=227' Tc=17.6 min CN=76 Runoff=3.59 cfs 0.409 af

Subcatchment 4S: LONGA Runoff Area=3.666 ac 17.46% Impervious Runoff Depth=2.65"
Flow Length=668' Tc=20.7 min CN=66 Runoff=6.45 cfs 0.809 af

Subcatchment 5S: MAYHEW-E Runoff Area=1.720 ac 23.55% Impervious Runoff Depth=2.93"
Flow Length=212' Tc=17.8 min CN=69 Runoff=3.63 cfs 0.420 af

Subcatchment 6S: MAYHEW-W Runoff Area=0.646 ac 27.24% Impervious Runoff Depth=2.93"
Flow Length=315' Tc=20.1 min CN=69 Runoff=1.29 cfs 0.158 af

Subcatchment 7S: MIRIAM Runoff Area=2.222 ac 29.21% Impervious Runoff Depth=3.13"
Flow Length=427' Tc=25.1 min CN=71 Runoff=4.29 cfs 0.579 af

Subcatchment 8S: RICHARDS Runoff Area=9.544 ac 6.16% Impervious Runoff Depth=2.20"
Flow Length=1,428' Tc=26.2 min CN=61 Runoff=12.02 cfs 1.746 af

Subcatchment 9S: SHORE Runoff Area=6.281 ac 22.00% Impervious Runoff Depth=2.84"
Flow Length=451' Tc=20.2 min CN=68 Runoff=12.07 cfs 1.485 af

Subcatchment 16S: RENNIE-N Runoff Area=0.359 ac 23.12% Impervious Runoff Depth=2.93"
Flow Length=174' Tc=14.3 min CN=69 Runoff=0.83 cfs 0.088 af

Subcatchment 17S: RENNIE-S Runoff Area=1.487 ac 19.17% Impervious Runoff Depth=2.65"
Flow Length=386' Tc=18.2 min CN=66 Runoff=2.78 cfs 0.328 af

Reach 12R: C-Miriam Avg. Flow Depth=0.44' Max Vel=12.81 fps Inflow=4.29 cfs 0.579 af
12.0" Round Pipe n=0.009 L=845.0' S=0.0428 '/' Capacity=10.65 cfs Outflow=4.25 cfs 0.579 af

Reach 13R: C-Arnold Avg. Flow Depth=0.96' Max Vel=6.98 fps Inflow=8.39 cfs 1.146 af
18.0" Round Pipe n=0.009 L=225.0' S=0.0055 '/' Capacity=11.26 cfs Outflow=8.35 cfs 1.146 af

Reach 14R: C-Carter-W Avg. Flow Depth=1.13' Max Vel=22.55 fps Inflow=41.40 cfs 6.067 af
24.0" Round Pipe n=0.009 L=260.0' S=0.0427 '/' Capacity=67.49 cfs Outflow=41.25 cfs 6.067 af

Reach 17R: C-Carter-E Avg. Flow Depth=0.56' Max Vel=16.50 fps Inflow=7.55 cfs 0.962 af
12.0" Round Pipe n=0.009 L=640.0' S=0.0578 '/' Capacity=12.37 cfs Outflow=7.49 cfs 0.962 af

Reach 18R: D-Mayhew Avg. Flow Depth=0.69' Max Vel=1.26 fps Inflow=3.63 cfs 0.420 af
n=0.150 L=275.1' S=0.0482 '/' Capacity=7.74 cfs Outflow=3.46 cfs 0.420 af

Reach 19R: C-Mayhew Avg. Flow Depth=0.41' Max Vel=15.14 fps Inflow=4.67 cfs 0.578 af
12.0" Round Pipe n=0.009 L=450.0' S=0.0633 '/' Capacity=12.95 cfs Outflow=4.64 cfs 0.578 af

Reach 20R: C-Rennie-N Avg. Flow Depth=0.95' Max Vel=15.96 fps Inflow=23.36 cfs 3.550 af
24.0" Round Pipe n=0.009 L=190.0' S=0.0247 '/' Capacity=51.39 cfs Outflow=23.33 cfs 3.550 af

Reach 21R: D-Longa Avg. Flow Depth=0.88' Max Vel=1.39 fps Inflow=6.45 cfs 0.809 af
n=0.150 L=725.6' S=0.0447 '/' Capacity=7.46 cfs Outflow=5.63 cfs 0.809 af

Reach 22R: C-Rennie-S Avg. Flow Depth=1.16' Max Vel=9.80 fps Inflow=18.54 cfs 2.884 af
24.0" Round Pipe n=0.012 L=235.0' S=0.0140 '/' Capacity=29.04 cfs Outflow=18.51 cfs 2.884 af

Reach 24R: C-Carter-C Avg. Flow Depth=0.96' Max Vel=20.35 fps Inflow=30.38 cfs 4.512 af
24.0" Round Pipe n=0.009 L=150.0' S=0.0396 '/' Capacity=65.03 cfs Outflow=30.36 cfs 4.512 af

Reach 25R: C-Carter-O Avg. Flow Depth=0.87' Max Vel=31.56 fps Inflow=41.25 cfs 6.067 af
24.0" Round Pipe n=0.009 L=210.0' S=0.1046 '/' Capacity=105.69 cfs Outflow=41.22 cfs 6.067 af

Link 15L: BAB Inflow=52.16 cfs 7.552 af
Primary=52.16 cfs 7.552 af

Total Runoff Area = 33.543 ac Runoff Volume = 7.552 af Average Runoff Depth = 2.70"
81.39% Pervious = 27.300 ac 18.61% Impervious = 6.243 ac

Summary for Subcatchment 1S: ARNOLD

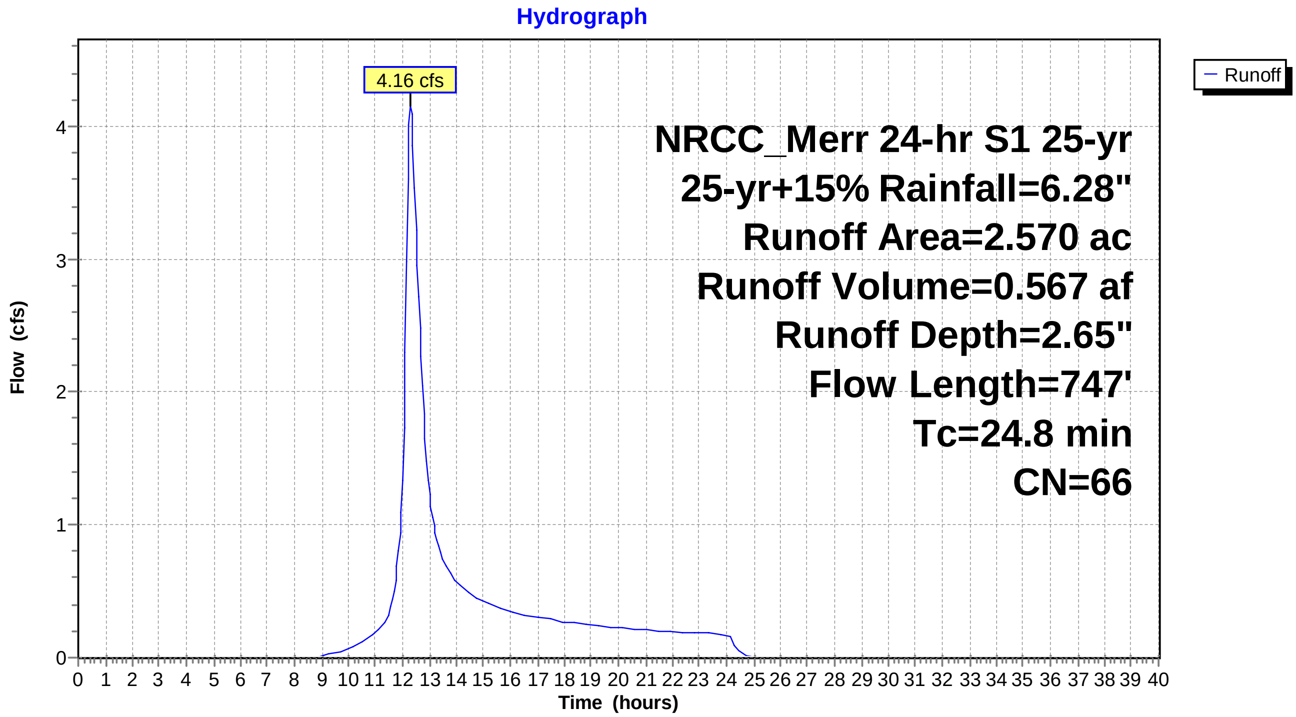
Runoff = 4.16 cfs @ 12.31 hrs, Volume= 0.567 af, Depth= 2.65"
Routed to Reach 13R : C-Arnold

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs
NRCC_Merr 24-hr S1 25-yr 25-yr+15% Rainfall=6.28"

	Area (ac)	CN	Description
*	0.224	98	Buildings
*	0.083	98	Paved Road
*	0.138	98	Paved Driveway
*	0.260	69	50-75% Grass cover, Fair, HSG B (lawn)
*	1.865	58	Woods/grass comb., Good, HSG B (open area)
	2.570	66	Weighted Average
	2.125		82.68% Pervious Area
	0.445		17.32% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
16.7	100	0.0412	0.10		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 2.96"
7.5	533	0.0564	1.19		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
0.5	99	0.0348	3.12	6.24	**Channel Flow, Assume 6"hx3'bx2H:1V** Area= 2.0 sf Perim= 10.2' r= 0.20' n= 0.030
0.1	15	0.0275	3.91	3.07	**Pipe Channel, assume 12" CMP from depression to CB** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.025 Corrugated metal
24.8	747	Total			

Subcatchment 1S: ARNOLD



Summary for Subcatchment 2S: CARTER-E

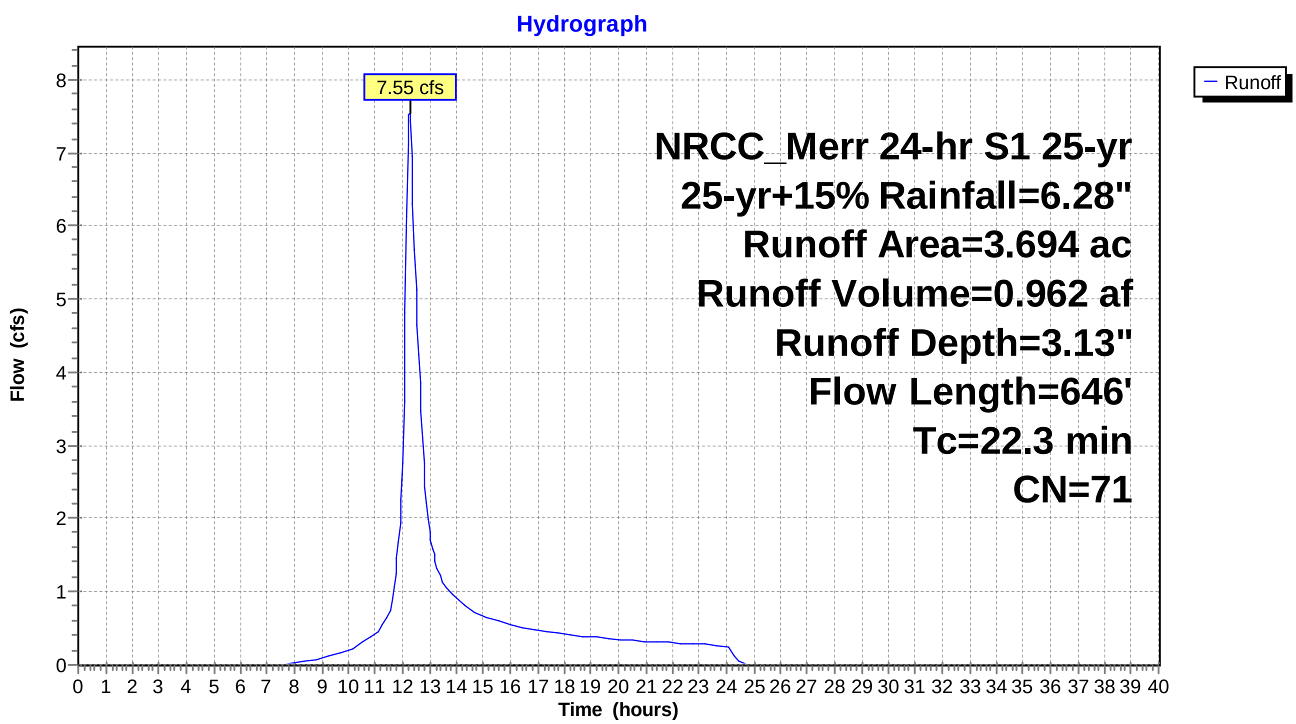
Runoff = 7.55 cfs @ 12.27 hrs, Volume= 0.962 af, Depth= 3.13"
Routed to Reach 17R : C-Carter-E

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs
NRCC_Merr 24-hr S1 25-yr 25-yr+15% Rainfall=6.28"

	Area (ac)	CN	Description
*	0.358	98	Buildings
*	0.448	98	Paved Road
*	0.261	98	Driveway
*	0.527	69	50-75% Grass cover, Fair, HSG B (lawn)
*	2.100	58	Woods/grass comb., Good, HSG B (open area)
	3.694	71	Weighted Average
	2.627		71.12% Pervious Area
	1.067		28.88% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.3	100	0.0607	0.12		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 2.96"
8.0	546	0.0523	1.14		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
22.3	646	Total			

Subcatchment 2S: CARTER-E



Summary for Subcatchment 3S: CARTER-W

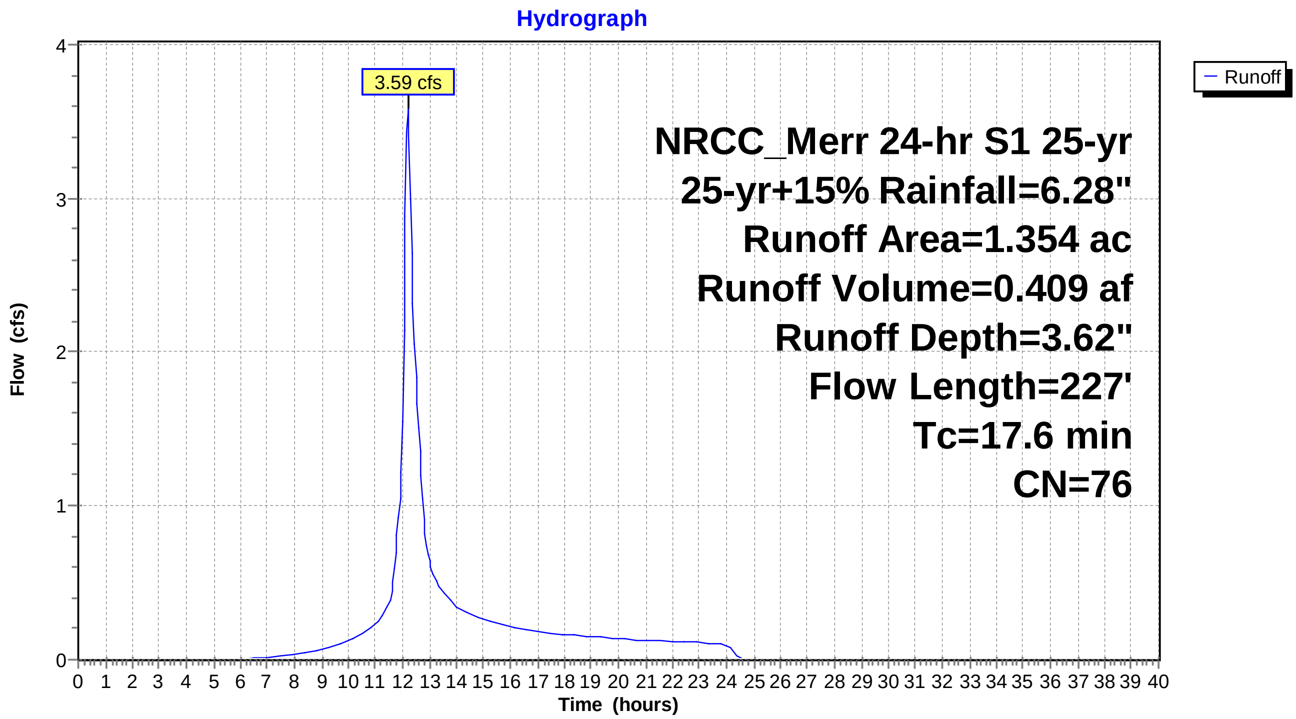
Runoff = 3.59 cfs @ 12.20 hrs, Volume= 0.409 af, Depth= 3.62"
Routed to Reach 14R : C-Carter-W

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs
NRCC_Merr 24-hr S1 25-yr 25-yr+15% Rainfall=6.28"

	Area (ac)	CN	Description
*	0.171	98	
*	0.221	98	
*	0.131	98	
	0.022	85	Gravel roads, HSG B
*	0.270	69	50-75% Grass cover, Fair, HSG B (lawn)
*	0.539	58	Woods/grass comb., Good, HSG B (open area)
	1.354	76	Weighted Average
	0.831		61.37% Pervious Area
	0.523		38.63% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.5	100	0.0495	0.11		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 2.96"
2.1	127	0.0405	1.01		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
17.6	227	Total			

Subcatchment 3S: CARTER-W



Summary for Subcatchment 4S: LONGA

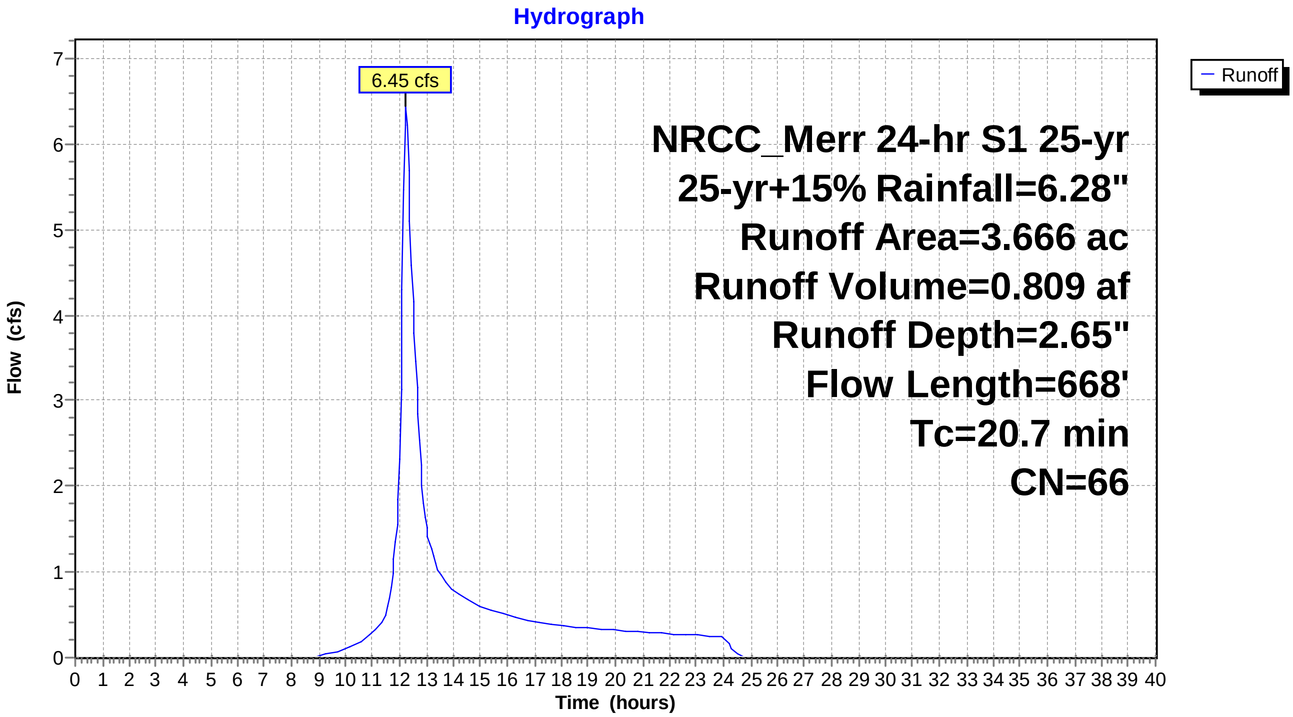
Runoff = 6.45 cfs @ 12.25 hrs, Volume= 0.809 af, Depth= 2.65"
Routed to Reach 21R : D-Longa

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs
NRCC_Merr 24-hr S1 25-yr 25-yr+15% Rainfall=6.28"

	Area (ac)	CN	Description
*	0.180	98	Buildings
*	0.341	98	Paved Roads
*	0.119	98	Paved Driveways
*	0.285	69	50-75% Grass cover, Fair, HSG B (lawn)
*	2.741	58	Woods/grass comb., Good, HSG B (open area)
	3.666	66	Weighted Average
	3.026		82.54% Pervious Area
	0.640		17.46% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.2	100	0.0526	0.11		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 2.96"
3.8	274	0.0593	1.22		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.7	294	0.0282	2.81	5.61	**Channel Flow, Assume 6"hx3'bx2H:1V** Area= 2.0 sf Perim= 10.2' r= 0.20' n= 0.030 Earth, grassed & winding
20.7	668	Total			

Subcatchment 4S: LONGA



Summary for Subcatchment 5S: MAYHEW-E

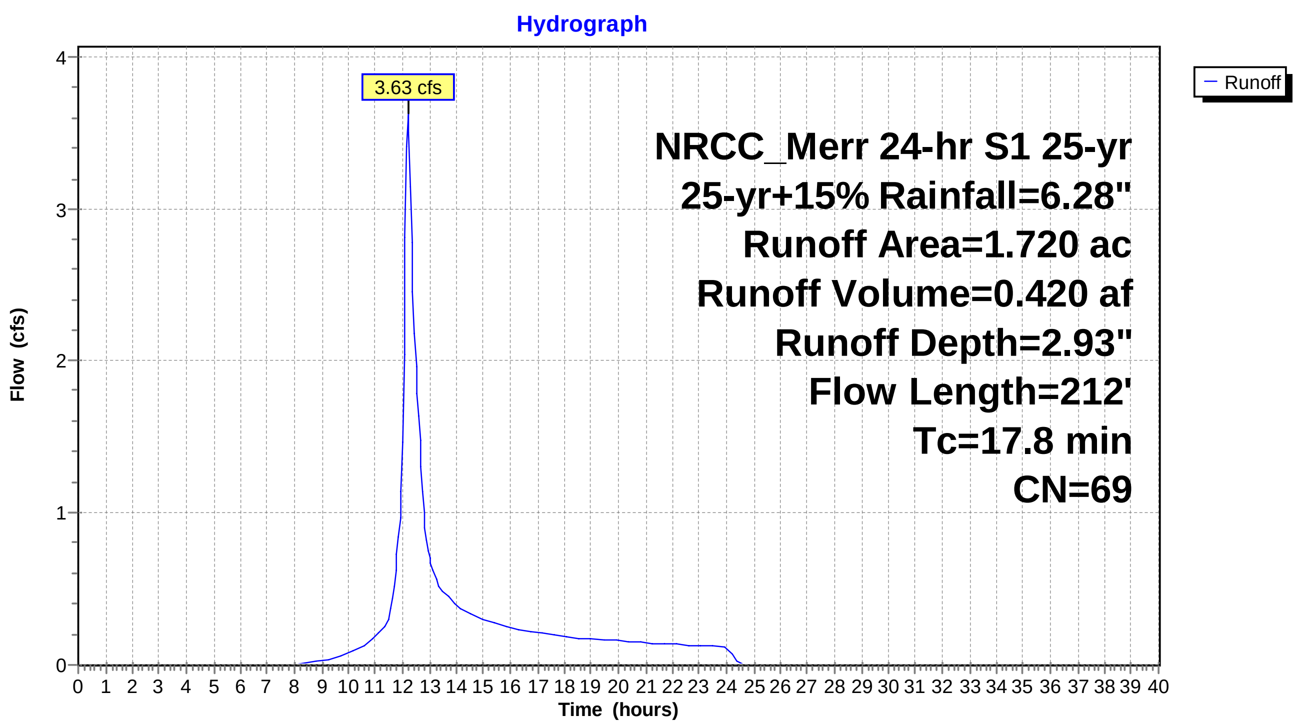
Runoff = 3.63 cfs @ 12.21 hrs, Volume= 0.420 af, Depth= 2.93"
Routed to Reach 18R : D-Mayhew

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs
NRCC_Merr 24-hr S1 25-yr 25-yr+15% Rainfall=6.28"

	Area (ac)	CN	Description
*	0.092	98	Building
*	0.189	98	Paved Rd
*	0.124	98	Paved Driveway
*	0.287	69	50-75% Grass cover, Fair, HSG B (lawn)
*	1.028	58	Woods/grass comb., Good, HSG B (open)
	1.720	69	Weighted Average
	1.315		76.45% Pervious Area
	0.405		23.55% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
16.0	100	0.0461	0.10		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 2.96"
1.8	112	0.0437	1.05		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
17.8	212	Total			

Subcatchment 5S: MAYHEW-E



Summary for Subcatchment 6S: MAYHEW-W

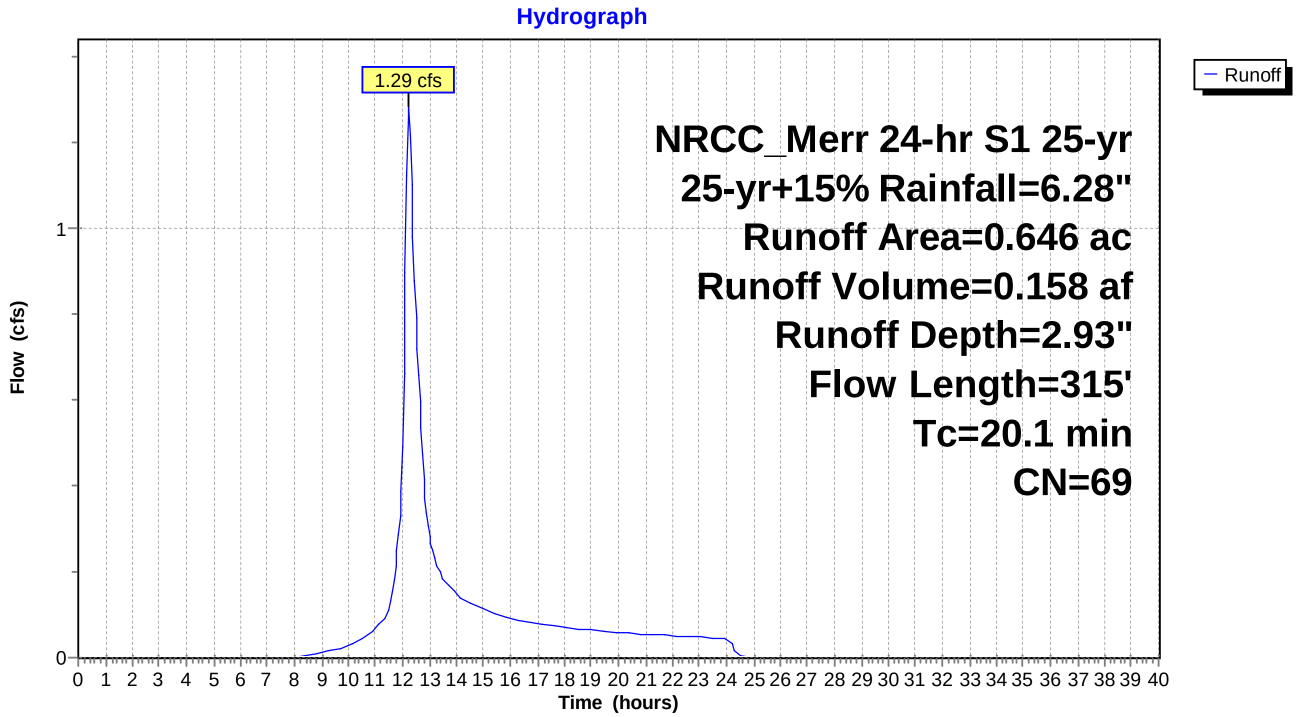
Runoff = 1.29 cfs @ 12.24 hrs, Volume= 0.158 af, Depth= 2.93"
Routed to Reach 19R : C-Mayhew

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs
NRCC_Merr 24-hr S1 25-yr 25-yr+15% Rainfall=6.28"

	Area (ac)	CN	Description
*	0.014	98	Buildings
*	0.138	98	Paved Rd
*	0.024	98	Paved Driveway
*	0.000	69	50-75% Grass cover, Fair, HSG B (lawn)
*	0.470	58	Woods/grass comb., Good, HSG B (open area)
	0.646	69	Weighted Average
	0.470		72.76% Pervious Area
	0.176		27.24% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
19.1	100	0.0295	0.09		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 2.96"
0.2	27	0.1356	1.84		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
0.8	188	0.0510	3.78	7.55	**Channel Flow, Assume 6"hx3'bx2H:1V** Area= 2.0 sf Perim= 10.2' r= 0.20' n= 0.030
20.1	315	Total			

Subcatchment 6S: MAYHEW-W



Summary for Subcatchment 7S: MIRIAM

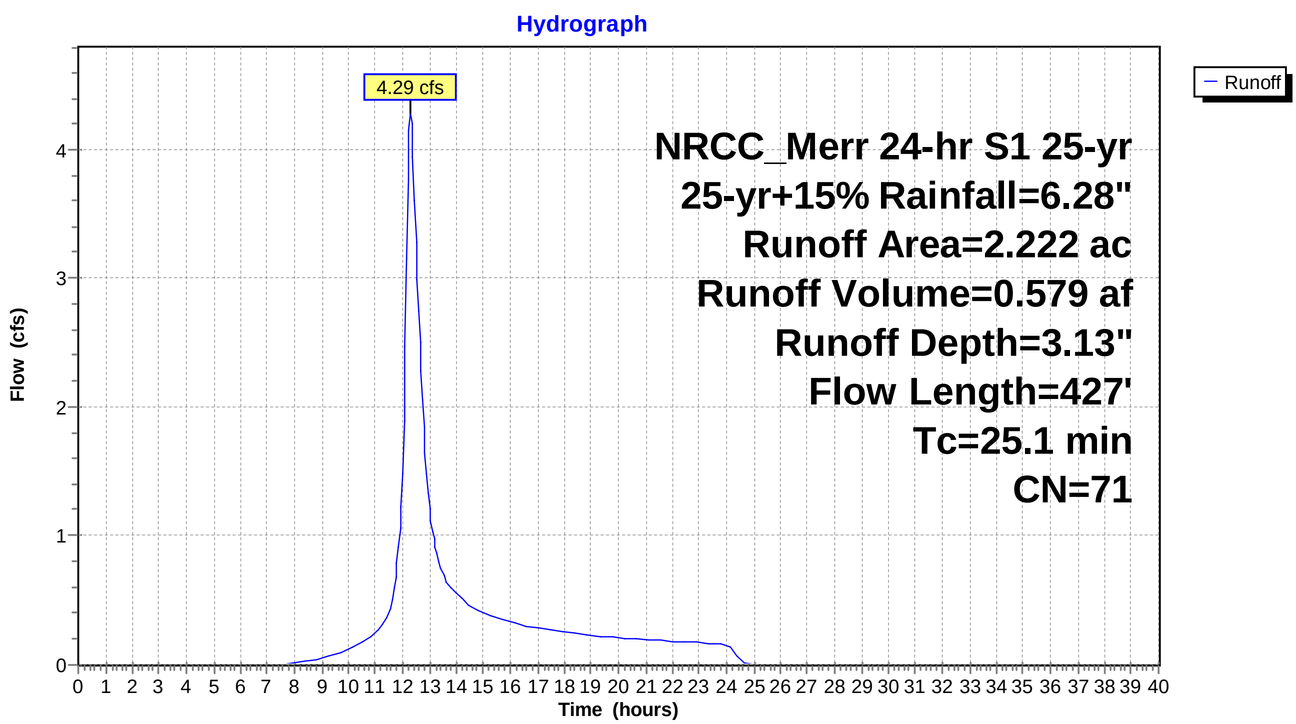
Runoff = 4.29 cfs @ 12.31 hrs, Volume= 0.579 af, Depth= 3.13"
Routed to Reach 12R : C-Miriam

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs
NRCC_Merr 24-hr S1 25-yr 25-yr+15% Rainfall=6.28"

	Area (ac)	CN	Description
*	0.147	98	Building
*	0.364	98	Paved Road
*	0.138	98	Paved Driveway
*	0.362	69	50-75% Grass cover, Fair, HSG B (lawn)
*	1.211	58	Woods/grass comb., Good, HSG B (open area)
	2.222	71	Weighted Average
	1.573		70.79% Pervious Area
	0.649		29.21% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
19.2	100	0.0291	0.09		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 2.96"
5.9	327	0.0339	0.92		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
25.1	427	Total			

Subcatchment 7S: MIRIAM



Summary for Subcatchment 8S: RICHARDS

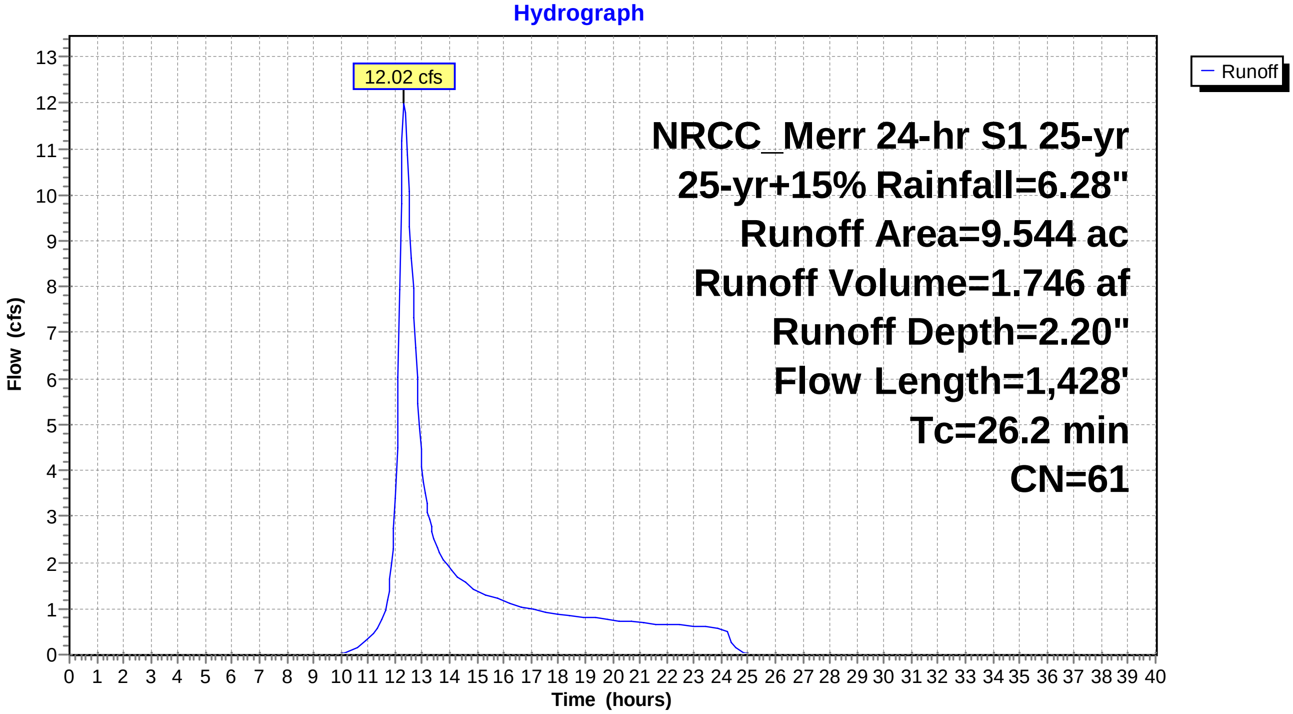
Runoff = 12.02 cfs @ 12.34 hrs, Volume= 1.746 af, Depth= 2.20"
Routed to Reach 22R : C-Rennie-S

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs
NRCC_Merr 24-hr S1 25-yr 25-yr+15% Rainfall=6.28"

	Area (ac)	CN	Description
*	0.173	98	Bldg
*	0.105	98	Paved Roads
*	0.310	98	Paved Driveways
*	0.528	69	50-75% Grass cover, Fair, HSG B (lawn)
*	8.428	58	Woods/grass comb., Good, HSG B (open area)
	9.544	61	Weighted Average
	8.956		93.84% Pervious Area
	0.588		6.16% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
14.3	100	0.0607	0.12		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 2.96"
5.6	339	0.0402	1.00		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
6.3	989	0.0245	2.62	5.23	**Channel Flow, Assume 6"hx3'bx2H:1V** Area= 2.0 sf Perim= 10.2' r= 0.20' n= 0.030
26.2	1,428	Total			

Subcatchment 8S: RICHARDS



Summary for Subcatchment 9S: SHORE

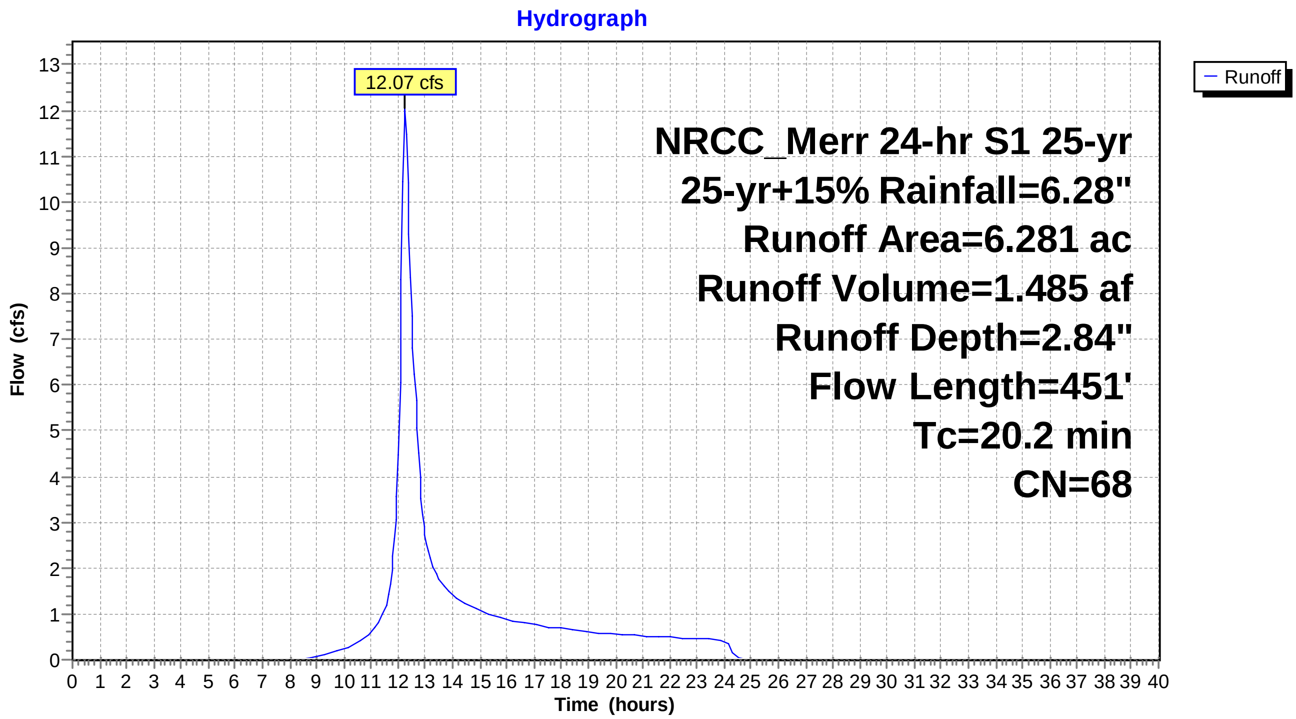
Runoff = 12.07 cfs @ 12.24 hrs, Volume= 1.485 af, Depth= 2.84"
Routed to Link 15L : BAB

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs
NRCC_Merr 24-hr S1 25-yr 25-yr+15% Rainfall=6.28"

	Area (ac)	CN	Description
*	0.502	98	
*	0.577	98	
*	0.303	98	
	0.046	85	Gravel roads, HSG B
*	0.453	69	50-75% Grass cover, Fair, HSG B (lawn)
*	4.400	58	Woods/grass comb., Good, HSG B (open area)
	6.281	68	Weighted Average
	4.899		78.00% Pervious Area
	1.382		22.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
16.2	100	0.0449	0.10		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 2.96"
4.0	351	0.0839	1.45		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
20.2	451	Total			

Subcatchment 9S: SHORE



Summary for Subcatchment 16S: RENNIE-N

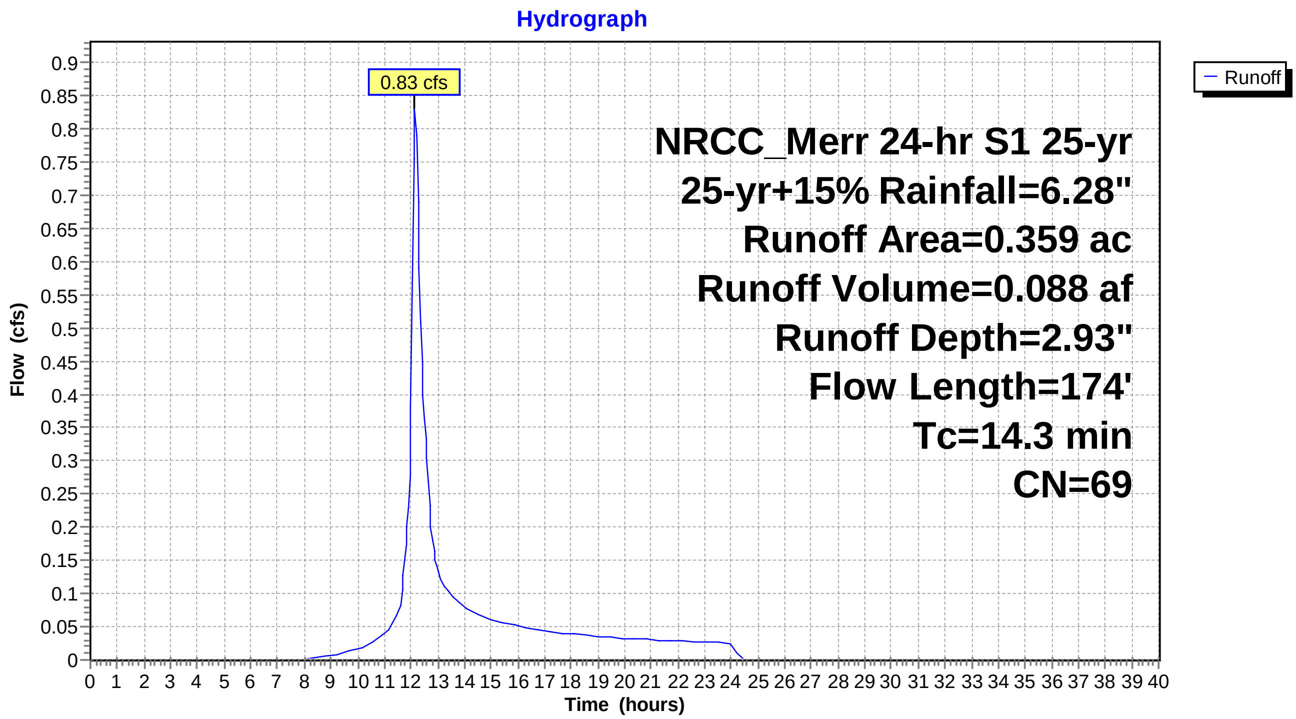
Runoff = 0.83 cfs @ 12.16 hrs, Volume= 0.088 af, Depth= 2.93"
Routed to Reach 20R : C-Rennie-N

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs
NRCC_Merr 24-hr S1 25-yr 25-yr+15% Rainfall=6.28"

	Area (ac)	CN	Description
*	0.027	98	Building
*	0.056	98	Paved Road
*	0.000	98	Paved Driveway
*	0.063	69	50-75% Grass cover, Fair, HSG B (lawn)
*	0.213	58	Woods/grass comb., Good, HSG B (open area)
	0.359	69	Weighted Average
	0.276		76.88% Pervious Area
	0.083		23.12% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.3	100	0.0737	0.13		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 2.96"
1.0	74	0.0584	1.21		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
14.3	174	Total			

Subcatchment 16S: RENNIE-N



Summary for Subcatchment 17S: RENNIE-S

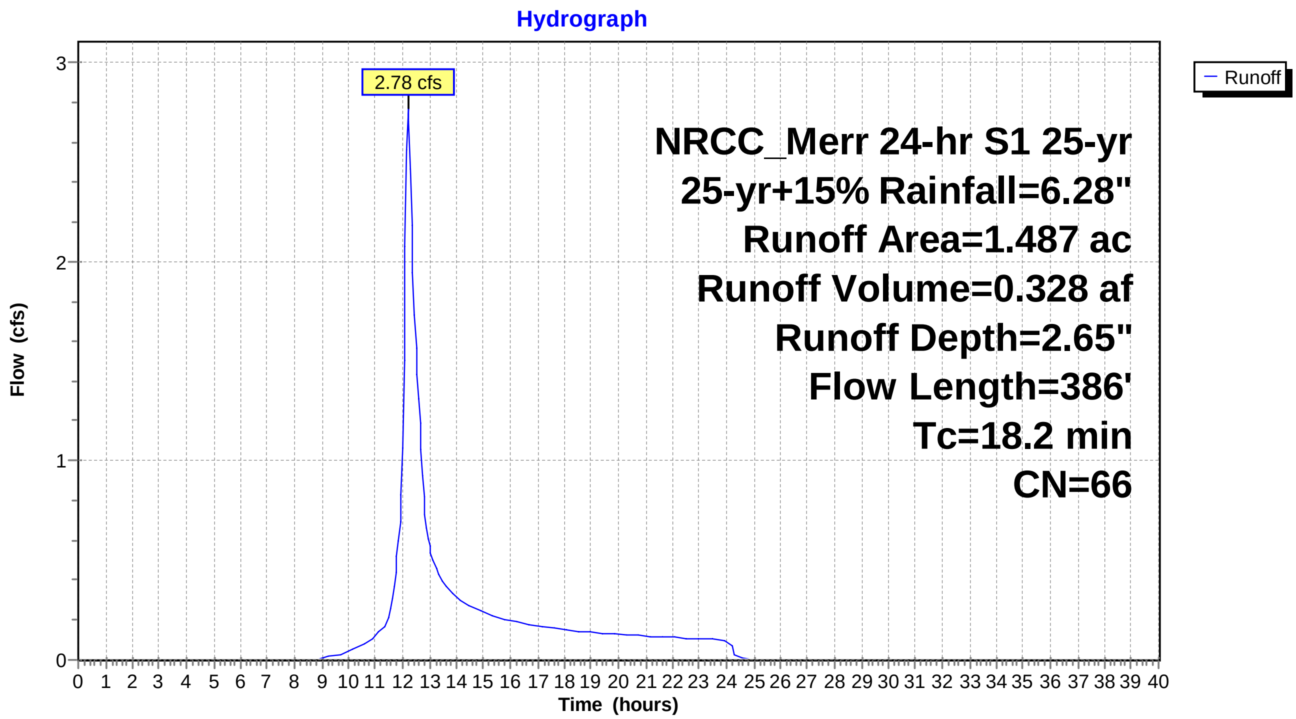
Runoff = 2.78 cfs @ 12.21 hrs, Volume= 0.328 af, Depth= 2.65"
Routed to Reach 22R : C-Rennie-S

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs
NRCC_Merr 24-hr S1 25-yr 25-yr+15% Rainfall=6.28"

	Area (ac)	CN	Description
*	0.107	98	Building
*	0.115	98	Paved Rd
*	0.063	98	Paved Driveway
*	0.082	69	50-75% Grass cover, Fair, HSG B (lawn)
*	1.120	58	Woods/grass comb., Good, HSG B (open area)
	1.487	66	Weighted Average
	1.202		80.83% Pervious Area
	0.285		19.17% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.9	100	0.0658	0.12		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 2.96"
4.3	286	0.0490	1.11		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
18.2	386	Total			

Subcatchment 17S: RENNIE-S



Summary for Reach 12R: C-Miriam

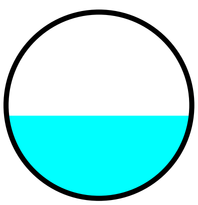
Pipe reach which runs along Miriam Rd to the intersection with Arnold Rd, said to begin 150ft from the watershed boundary

Inflow Area = 2.222 ac, 29.21% Impervious, Inflow Depth = 3.13" for 25-yr+15% event
Inflow = 4.29 cfs @ 12.31 hrs, Volume= 0.579 af
Outflow = 4.25 cfs @ 12.34 hrs, Volume= 0.579 af, Atten= 1%, Lag= 2.0 min
Routed to Reach 13R : C-Arnold

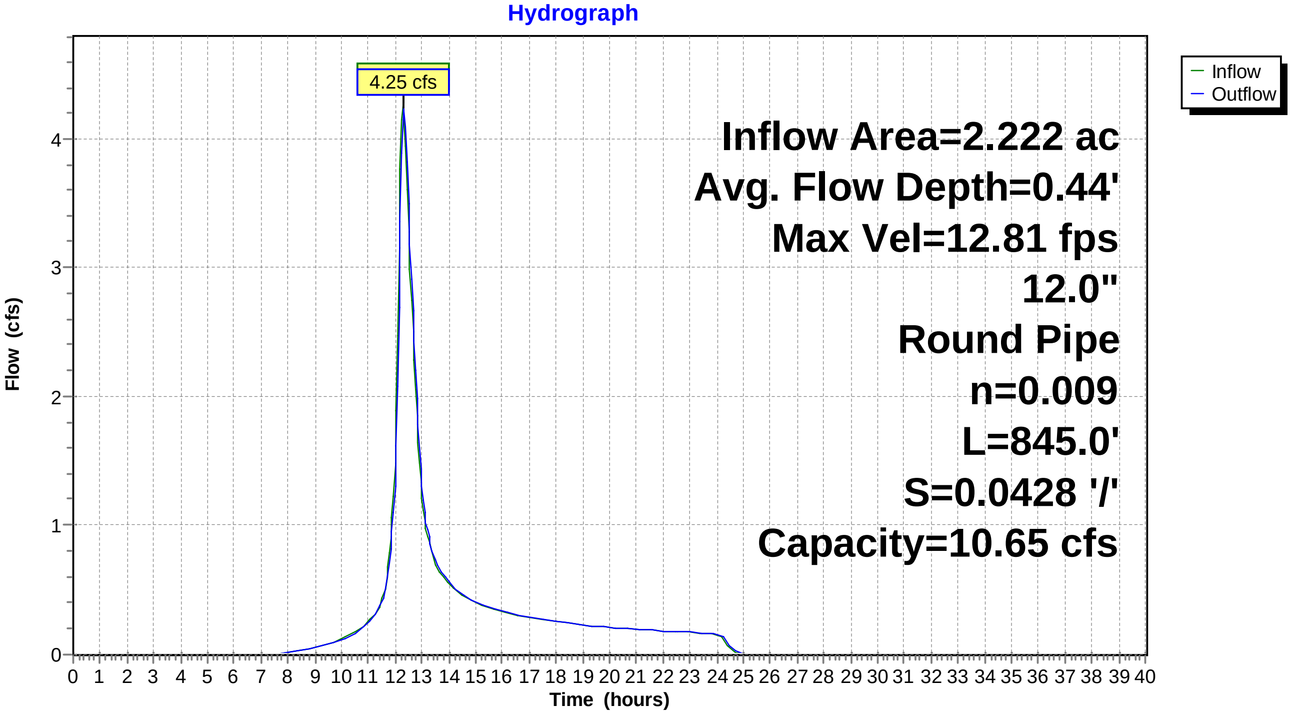
Routing by Stor-Ind+Trans method, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs
Max. Velocity= 12.81 fps, Min. Travel Time= 1.1 min
Avg. Velocity = 5.45 fps, Avg. Travel Time= 2.6 min

Peak Storage= 282 cf @ 12.32 hrs
Average Depth at Peak Storage= 0.44' , Surface Width= 0.99'
Bank-Full Depth= 1.00' Flow Area= 0.8 sf, Capacity= 10.65 cfs

12.0" Round Pipe
n= 0.009
Length= 845.0' Slope= 0.0428 '/'
Inlet Invert= 321.30', Outlet Invert= 285.10'



Reach 12R: C-Miriam



Summary for Reach 13R: C-Arnold

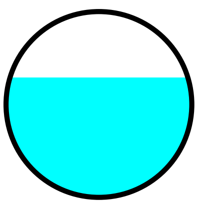
Pipe which runs from the intersection with miriam to the intersection with Carter

Inflow Area = 4.792 ac, 22.83% Impervious, Inflow Depth = 2.87" for 25-yr+15% event
Inflow = 8.39 cfs @ 12.32 hrs, Volume= 1.146 af
Outflow = 8.35 cfs @ 12.34 hrs, Volume= 1.146 af, Atten= 1%, Lag= 1.1 min
Routed to Reach 14R : C-Carter-W

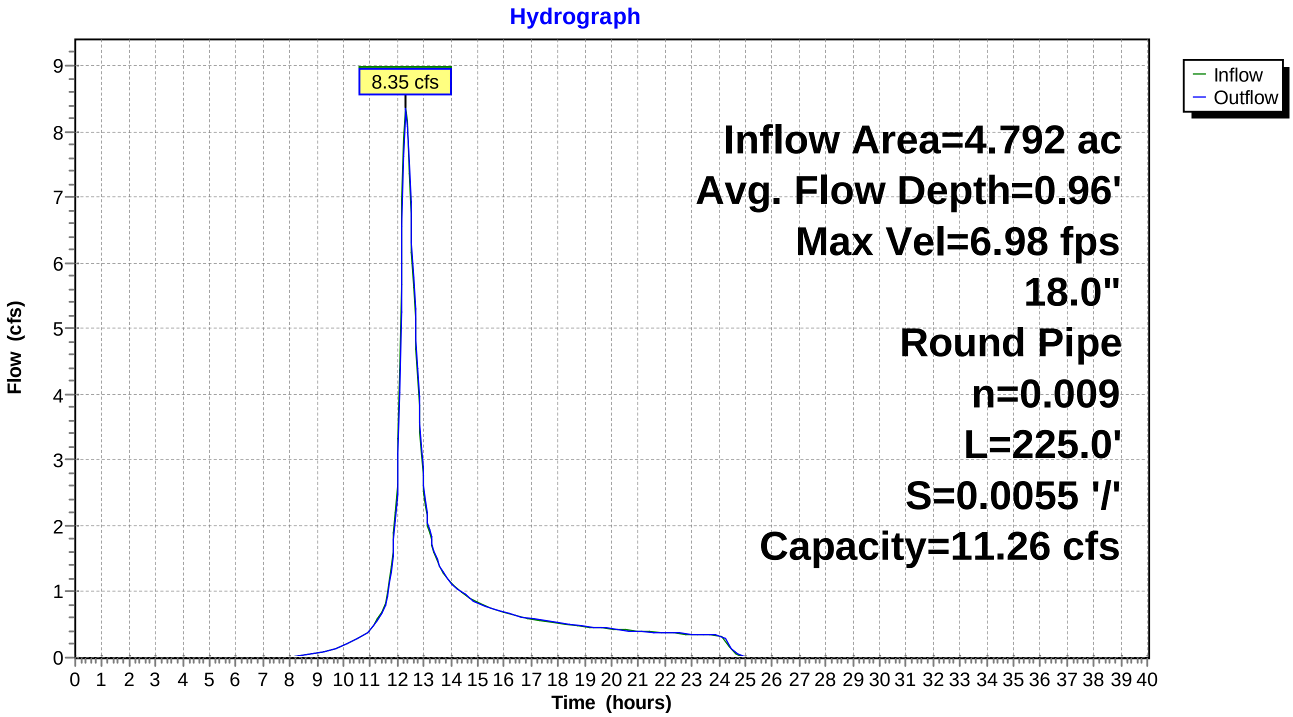
Routing by Stor-Ind+Trans method, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs
Max. Velocity= 6.98 fps, Min. Travel Time= 0.5 min
Avg. Velocity = 3.01 fps, Avg. Travel Time= 1.2 min

Peak Storage= 270 cf @ 12.33 hrs
Average Depth at Peak Storage= 0.96' , Surface Width= 1.44'
Bank-Full Depth= 1.50' Flow Area= 1.8 sf, Capacity= 11.26 cfs

18.0" Round Pipe
n= 0.009
Length= 225.0' Slope= 0.0055 '/'
Inlet Invert= 285.10', Outlet Invert= 283.86'



Reach 13R: C-Arnold



Summary for Reach 14R: C-Carter-W

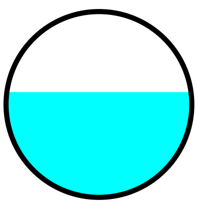
Pipe which runs along carter from intersection with arnold to the intersection with shore

Inflow Area = 27.262 ac, 17.83% Impervious, Inflow Depth = 2.67" for 25-yr+15% event
Inflow = 41.40 cfs @ 12.34 hrs, Volume= 6.067 af
Outflow = 41.25 cfs @ 12.34 hrs, Volume= 6.067 af, Atten= 0%, Lag= 0.4 min
Routed to Reach 25R : C-Carter-O

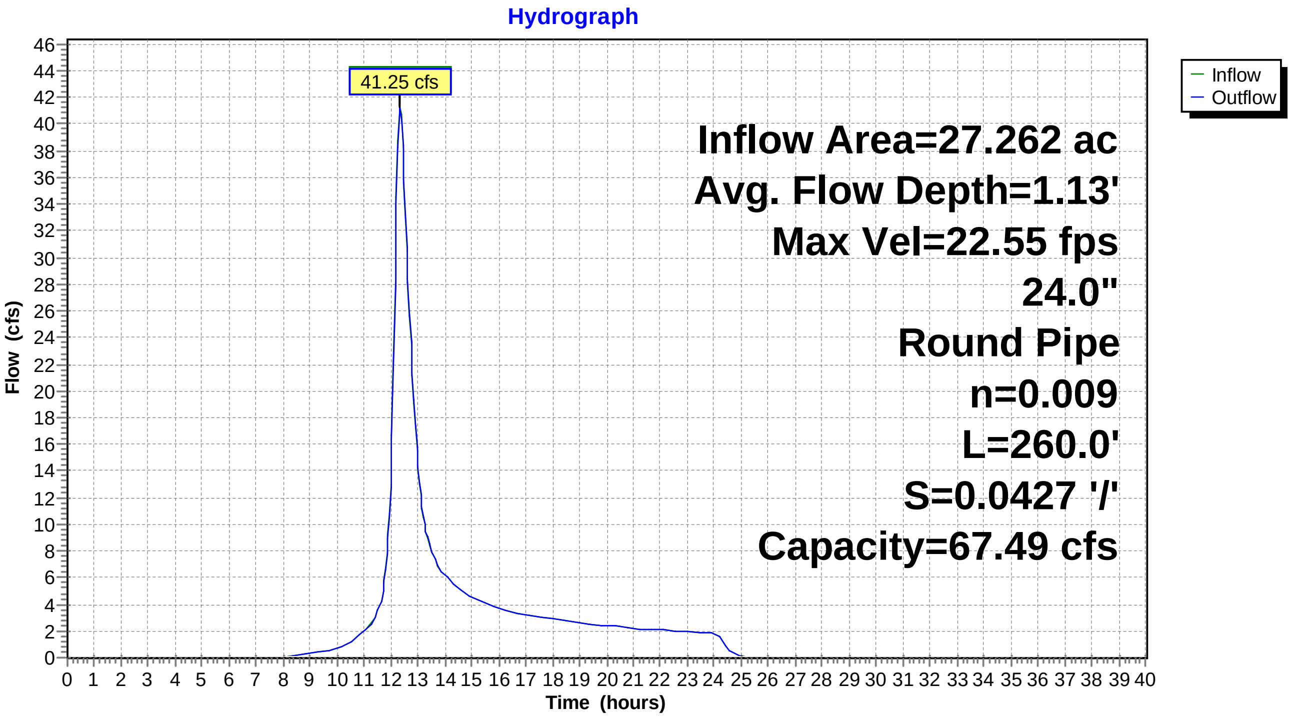
Routing by Stor-Ind+Trans method, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs / 2
Max. Velocity= 22.55 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 7.51 fps, Avg. Travel Time= 0.6 min

Peak Storage= 476 cf @ 12.34 hrs
Average Depth at Peak Storage= 1.13' , Surface Width= 1.98'
Bank-Full Depth= 2.00' Flow Area= 3.1 sf, Capacity= 67.49 cfs

24.0" Round Pipe
n= 0.009
Length= 260.0' Slope= 0.0427 '/'
Inlet Invert= 283.86', Outlet Invert= 272.77'



Reach 14R: C-Carter-W



Summary for Reach 17R: C-Carter-E

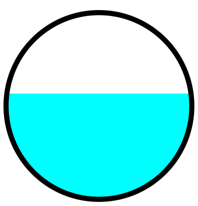
Pipe reach which runs along Carter between intersections with Rennie and Arnold

Inflow Area = 3.694 ac, 28.88% Impervious, Inflow Depth = 3.13" for 25-yr+15% event
Inflow = 7.55 cfs @ 12.27 hrs, Volume= 0.962 af
Outflow = 7.49 cfs @ 12.29 hrs, Volume= 0.962 af, Atten= 1%, Lag= 1.2 min
Routed to Reach 24R : C-Carter-C

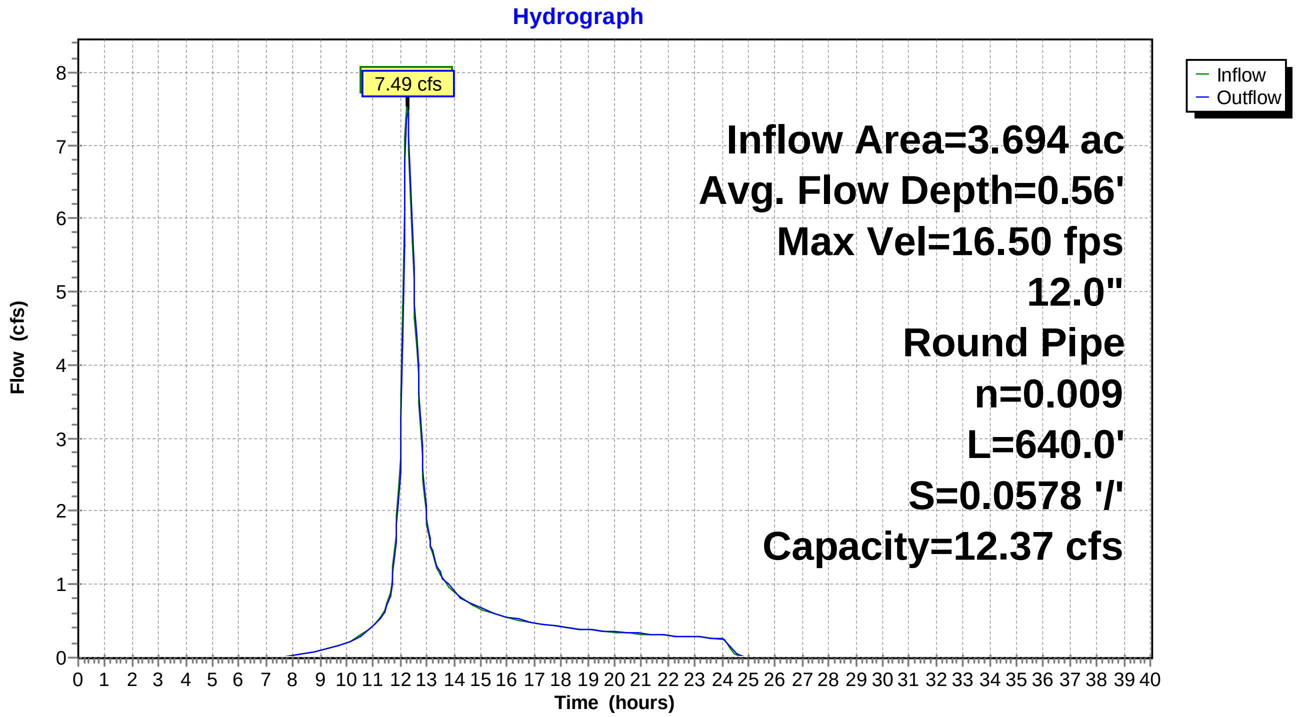
Routing by Stor-Ind+Trans method, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs
Max. Velocity= 16.50 fps, Min. Travel Time= 0.6 min
Avg. Velocity = 7.08 fps, Avg. Travel Time= 1.5 min

Peak Storage= 292 cf @ 12.27 hrs
Average Depth at Peak Storage= 0.56' , Surface Width= 0.99'
Bank-Full Depth= 1.00' Flow Area= 0.8 sf, Capacity= 12.37 cfs

12.0" Round Pipe
n= 0.009
Length= 640.0' Slope= 0.0578 '/'
Inlet Invert= 326.80', Outlet Invert= 289.80'



Reach 17R: C-Carter-E



Summary for Reach 18R: D-Mayhew

Vegetated swale reach running along Mayhew Rd, said to begin 150 from the watershed boundary and end at the town-owned lot where water features will be located

Inflow Area = 1.720 ac, 23.55% Impervious, Inflow Depth = 2.93" for 25-yr+15% event
Inflow = 3.63 cfs @ 12.21 hrs, Volume= 0.420 af
Outflow = 3.46 cfs @ 12.32 hrs, Volume= 0.420 af, Atten= 5%, Lag= 6.6 min
Routed to Reach 19R : C-Mayhew

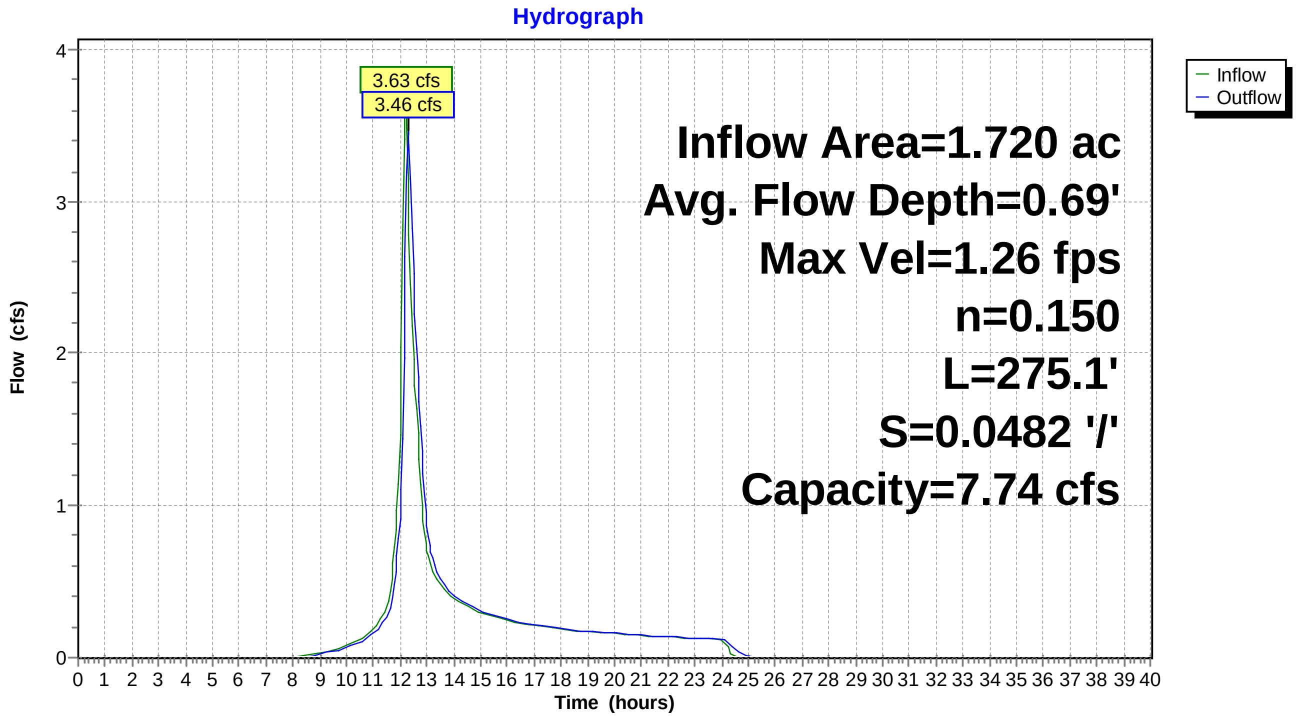
Routing by Stor-Ind+Trans method, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.26 fps, Min. Travel Time= 3.7 min
Avg. Velocity = 0.44 fps, Avg. Travel Time= 10.5 min

Peak Storage= 765 cf @ 12.26 hrs
Average Depth at Peak Storage= 0.69' , Surface Width= 6.11'
Bank-Full Depth= 1.00' Flow Area= 5.0 sf, Capacity= 7.74 cfs

2.00' x 1.00' deep channel, n= 0.150
Side Slope Z-value= 3.0 '/' Top Width= 8.00'
Length= 275.1' Slope= 0.0482 '/'
Inlet Invert= 338.44', Outlet Invert= 325.19'

‡

Reach 18R: D-Mayhew



Summary for Reach 19R: C-Mayhew

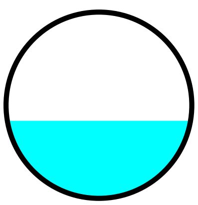
Pipe reach running along Mayhew Rd to intersection with Rennie Rd, here said to begin as soon as the vegetated swale ends

Inflow Area = 2.366 ac, 24.56% Impervious, Inflow Depth = 2.93" for 25-yr+15% event
Inflow = 4.67 cfs @ 12.30 hrs, Volume= 0.578 af
Outflow = 4.64 cfs @ 12.32 hrs, Volume= 0.578 af, Atten= 1%, Lag= 0.9 min
Routed to Reach 20R : C-Rennie-N

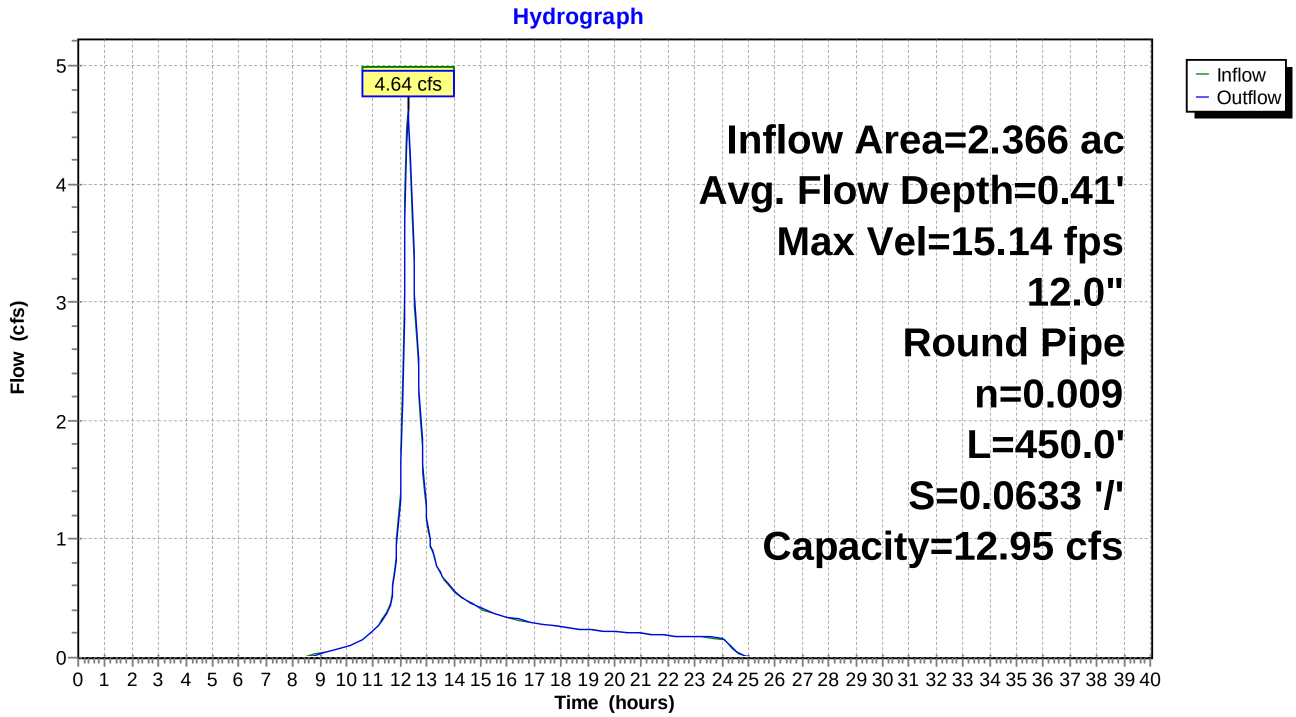
Routing by Stor-Ind+Trans method, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs
Max. Velocity= 15.14 fps, Min. Travel Time= 0.5 min
Avg. Velocity = 5.87 fps, Avg. Travel Time= 1.3 min

Peak Storage= 139 cf @ 12.31 hrs
Average Depth at Peak Storage= 0.41' , Surface Width= 0.99'
Bank-Full Depth= 1.00' Flow Area= 0.8 sf, Capacity= 12.95 cfs

12.0" Round Pipe
n= 0.009
Length= 450.0' Slope= 0.0633 '/'
Inlet Invert= 323.00', Outlet Invert= 294.50'



Reach 19R: C-Mayhew



Summary for Reach 20R: C-Rennie-N

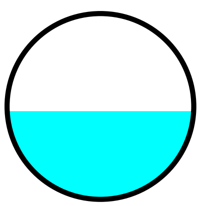
Pipe reach running along Rennie Rd between intersection with Mayhew Rd and intersection with Carter Rd

Inflow Area = 17.422 ac, 12.50% Impervious, Inflow Depth = 2.44" for 25-yr+15% event
Inflow = 23.36 cfs @ 12.37 hrs, Volume= 3.550 af
Outflow = 23.33 cfs @ 12.37 hrs, Volume= 3.550 af, Atten= 0%, Lag= 0.3 min
Routed to Reach 24R : C-Carter-C

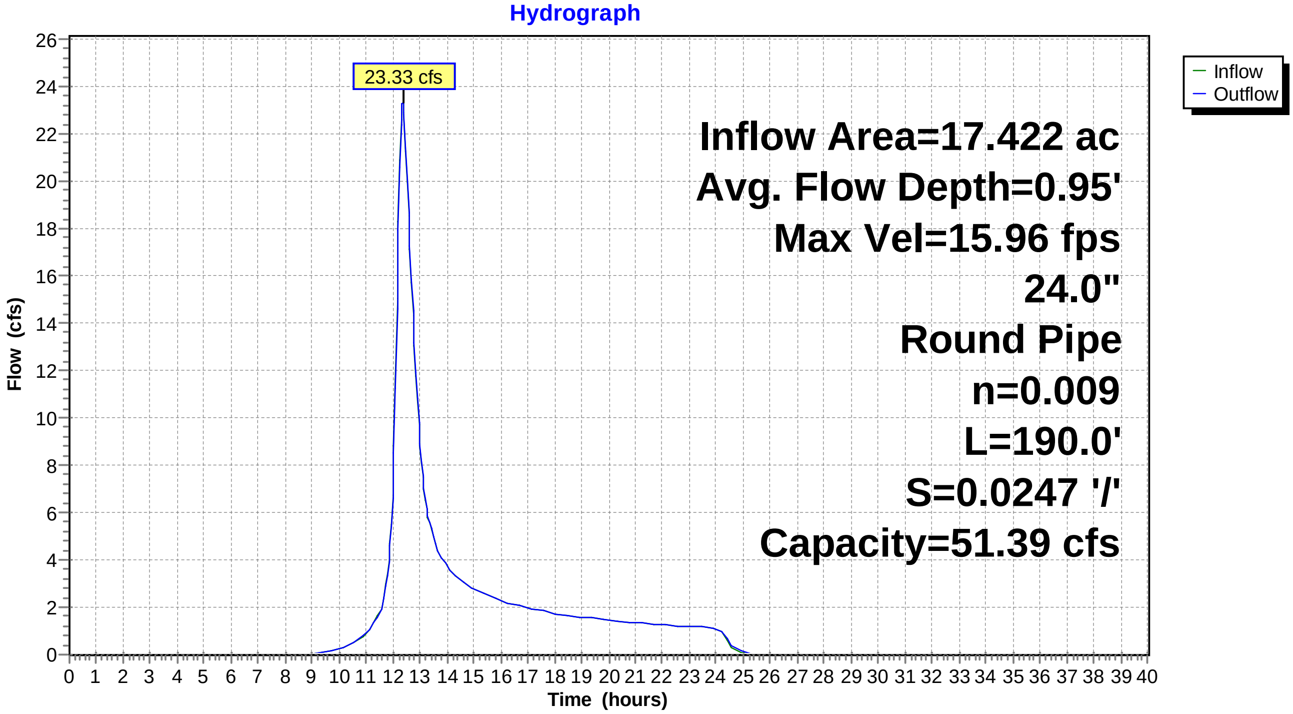
Routing by Stor-Ind+Trans method, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs
Max. Velocity= 15.96 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 5.43 fps, Avg. Travel Time= 0.6 min

Peak Storage= 278 cf @ 12.37 hrs
Average Depth at Peak Storage= 0.95' , Surface Width= 2.00'
Bank-Full Depth= 2.00' Flow Area= 3.1 sf, Capacity= 51.39 cfs

24.0" Round Pipe
n= 0.009
Length= 190.0' Slope= 0.0247 '/'
Inlet Invert= 294.50', Outlet Invert= 289.80'



Reach 20R: C-Rennie-N



Summary for Reach 21R: D-Longa

Vegegtated swale running along the eastern part of Longa, here said to start 150ft from the edge of the watershed (see CAD files) to intersection with Rennie

Inflow Area = 3.666 ac, 17.46% Impervious, Inflow Depth = 2.65" for 25-yr+15% event
Inflow = 6.45 cfs @ 12.25 hrs, Volume= 0.809 af
Outflow = 5.63 cfs @ 12.51 hrs, Volume= 0.809 af, Atten= 13%, Lag= 15.4 min
Routed to Reach 22R : C-Rennie-S

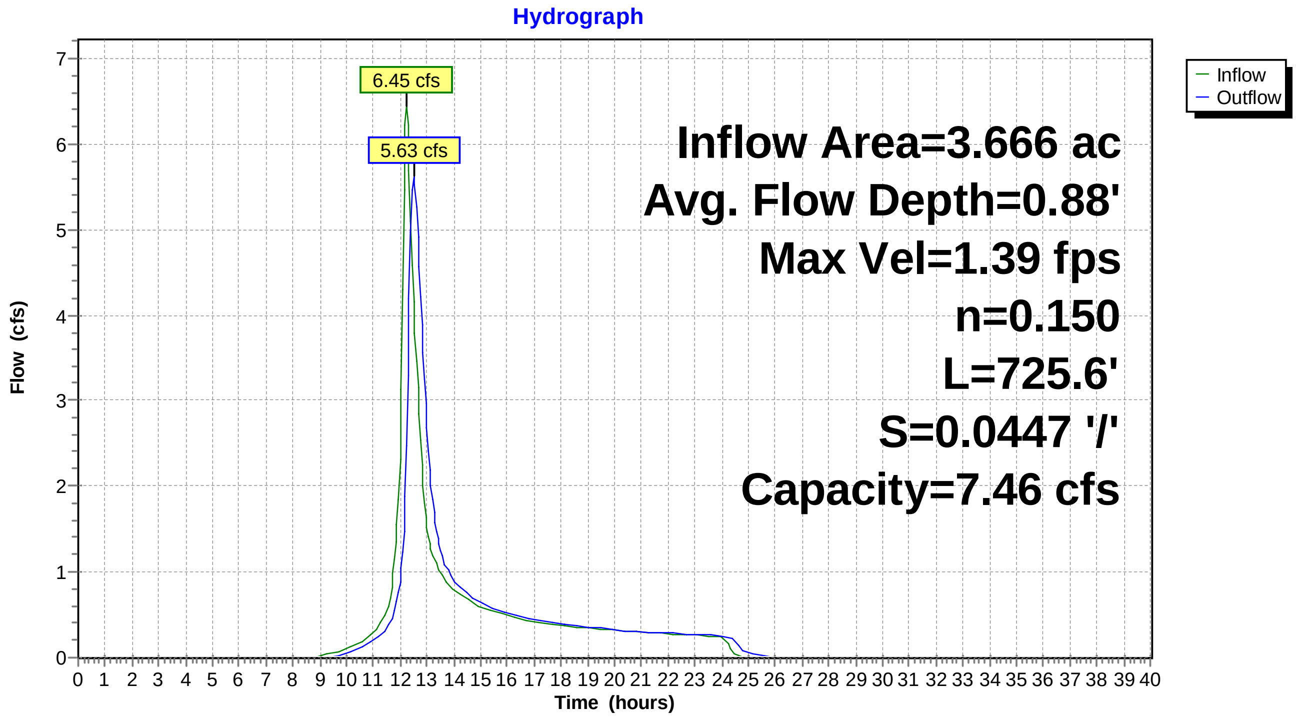
Routing by Stor-Ind+Trans method, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.39 fps, Min. Travel Time= 8.7 min
Avg. Velocity = 0.40 fps, Avg. Travel Time= 30.1 min

Peak Storage= 2,951 cf @ 12.36 hrs
Average Depth at Peak Storage= 0.88' , Surface Width= 7.27'
Bank-Full Depth= 1.00' Flow Area= 5.0 sf, Capacity= 7.46 cfs

2.00' x 1.00' deep channel, n= 0.150
Side Slope Z-value= 3.0 '/' Top Width= 8.00'
Length= 725.6' Slope= 0.0447 '/'
Inlet Invert= 335.01', Outlet Invert= 302.54'

‡

Reach 21R: D-Longa



Summary for Reach 22R: C-Rennie-S

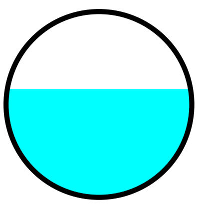
Pipe running along Rennie from the intersection with the east part of Longa to the intersection with Mayhew

Inflow Area = 14.697 ac, 10.29% Impervious, Inflow Depth = 2.35" for 25-yr+15% event
Inflow = 18.54 cfs @ 12.39 hrs, Volume= 2.884 af
Outflow = 18.51 cfs @ 12.40 hrs, Volume= 2.884 af, Atten= 0%, Lag= 0.7 min
Routed to Reach 20R : C-Rennie-N

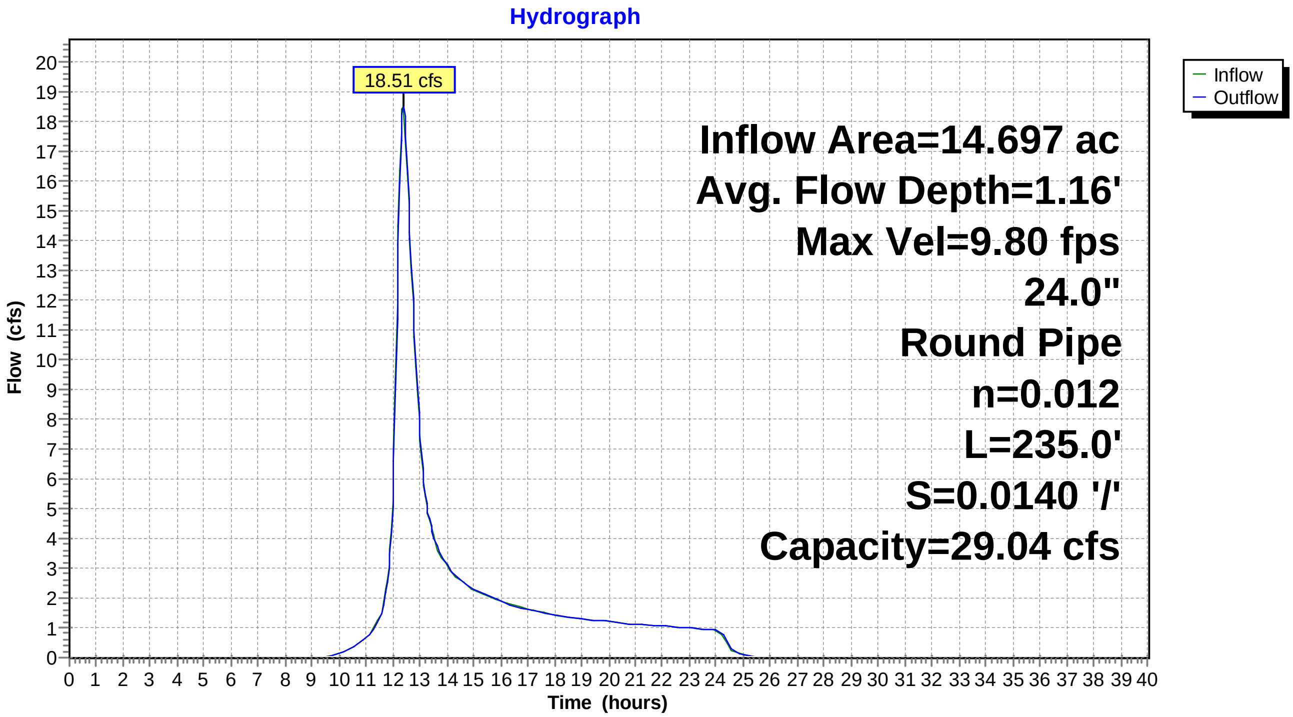
Routing by Stor-Ind+Trans method, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs
Max. Velocity= 9.80 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 3.31 fps, Avg. Travel Time= 1.2 min

Peak Storage= 445 cf @ 12.39 hrs
Average Depth at Peak Storage= 1.16' , Surface Width= 1.97'
Bank-Full Depth= 2.00' Flow Area= 3.1 sf, Capacity= 29.04 cfs

24.0" Round Pipe
n= 0.012
Length= 235.0' Slope= 0.0140 '/'
Inlet Invert= 297.80', Outlet Invert= 294.50'



Reach 22R: C-Rennie-S



Summary for Reach 24R: C-Carter-C

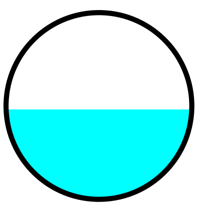
pipe which runs along carter between intersection with rennie and intersection with arnold

Inflow Area = 21.116 ac, 15.36% Impervious, Inflow Depth = 2.56" for 25-yr+15% event
Inflow = 30.38 cfs @ 12.35 hrs, Volume= 4.512 af
Outflow = 30.36 cfs @ 12.35 hrs, Volume= 4.512 af, Atten= 0%, Lag= 0.2 min
Routed to Reach 14R : C-Carter-W

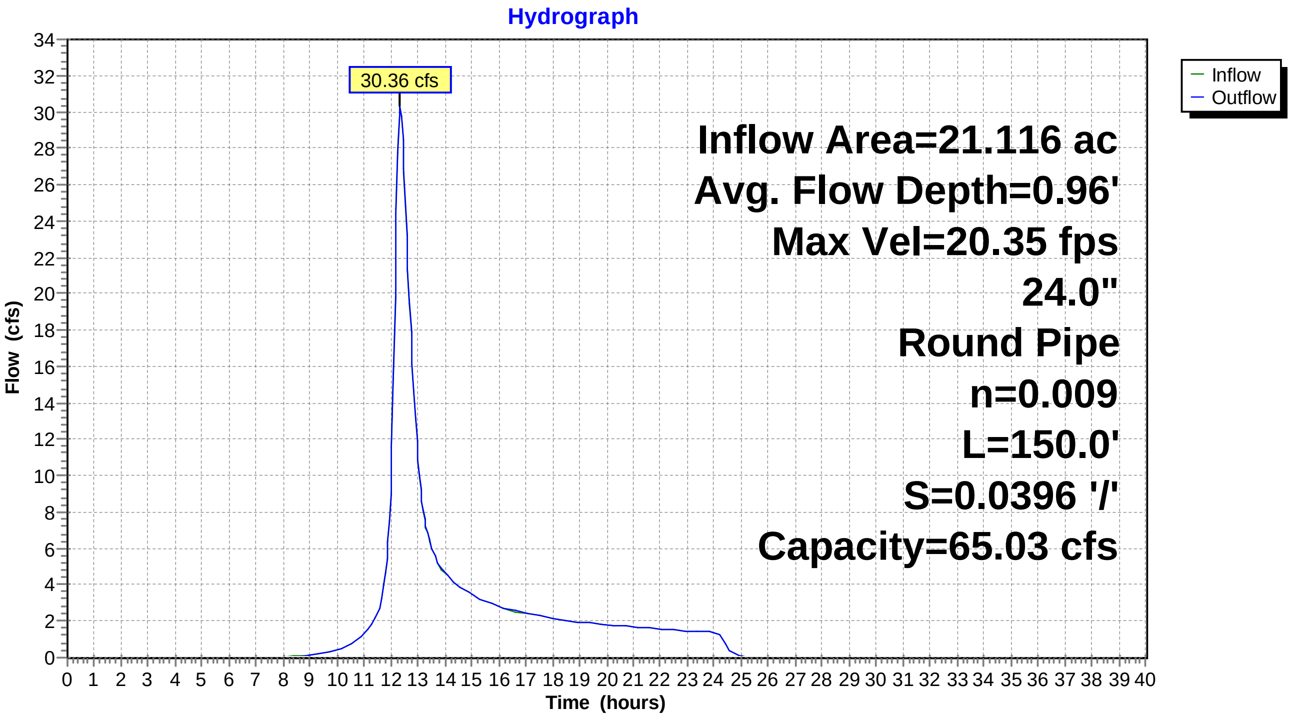
Routing by Stor-Ind+Trans method, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs
Max. Velocity= 20.35 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 6.95 fps, Avg. Travel Time= 0.4 min

Peak Storage= 224 cf @ 12.35 hrs
Average Depth at Peak Storage= 0.96' , Surface Width= 2.00'
Bank-Full Depth= 2.00' Flow Area= 3.1 sf, Capacity= 65.03 cfs

24.0" Round Pipe
n= 0.009
Length= 150.0' Slope= 0.0396 '/'
Inlet Invert= 289.80', Outlet Invert= 283.86'



Reach 24R: C-Carter-C



Summary for Reach 25R: C-Carter-O

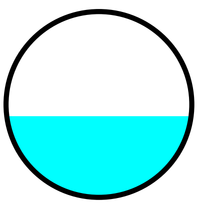
pipe running from intersection of carter and shore to outfall at baboosic

Inflow Area = 27.262 ac, 17.83% Impervious, Inflow Depth = 2.67" for 25-yr+15% event
Inflow = 41.25 cfs @ 12.34 hrs, Volume= 6.067 af
Outflow = 41.22 cfs @ 12.35 hrs, Volume= 6.067 af, Atten= 0%, Lag= 0.2 min
Routed to Link 15L : BAB

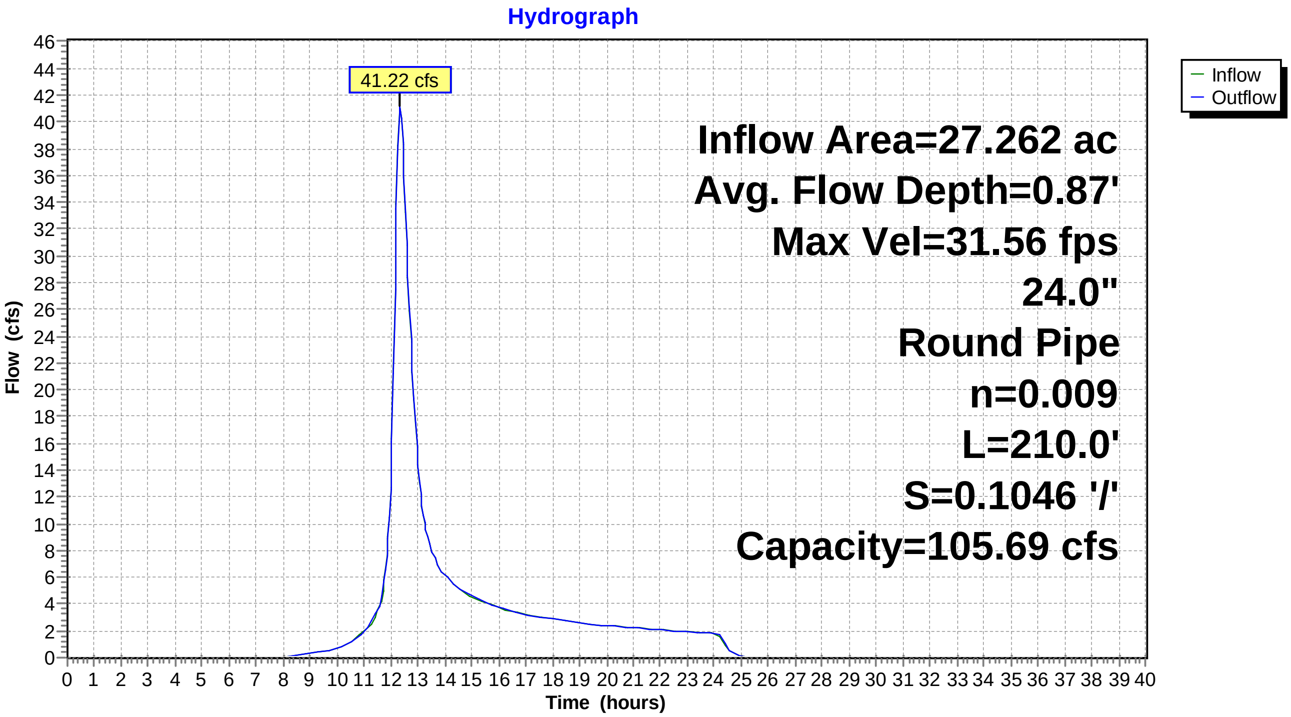
Routing by Stor-Ind+Trans method, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs
Max. Velocity= 31.56 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 10.70 fps, Avg. Travel Time= 0.3 min

Peak Storage= 274 cf @ 12.34 hrs
Average Depth at Peak Storage= 0.87' , Surface Width= 1.98'
Bank-Full Depth= 2.00' Flow Area= 3.1 sf, Capacity= 105.69 cfs

24.0" Round Pipe
n= 0.009
Length= 210.0' Slope= 0.1046 '/'
Inlet Invert= 272.77', Outlet Invert= 250.80'



Reach 25R: C-Carter-O

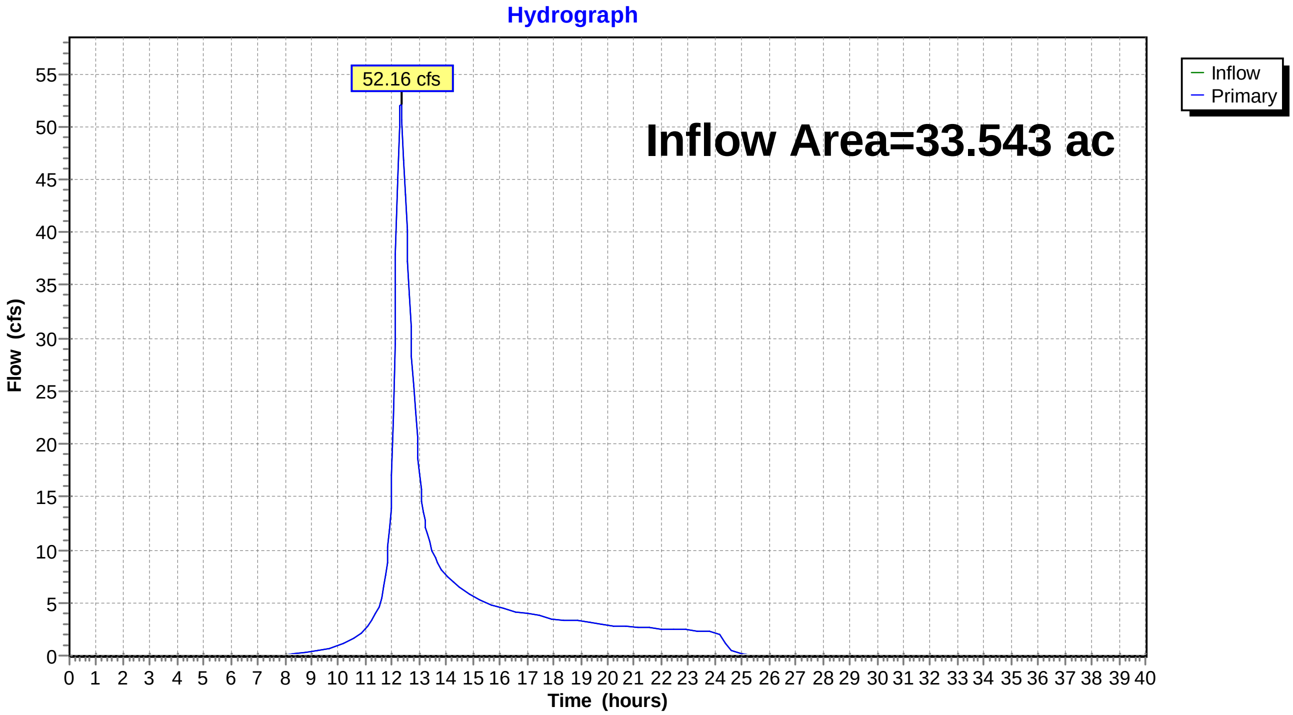


Summary for Link 15L: BAB

Inflow Area = 33.543 ac, 18.61% Impervious, Inflow Depth = 2.70" for 25-yr+15% event
Inflow = 52.16 cfs @ 12.32 hrs, Volume= 7.552 af
Primary = 52.16 cfs @ 12.32 hrs, Volume= 7.552 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs

Link 15L: BAB



Pipe Capacity: Lower Carter Road

Performed by: CMD Date: 9/28/2022

AECOM

Pipe Capacity Check - Manning's Pipe Flow

$$Q = \frac{K}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}$$

Q = Flow rate
K = 1.486 for USCS unit
n = Manning's roughness coefficient
R = Hydraulic radius
S = Slope
A = Area

Parameter	*Value*	*Units*	Notes:
Diameter	1.25	ft	Outfall diameter
Perimeter	3.93	ft	Circular pipe, flow full
Area	1.23	ft^2	Circular pipe
R	0.31	ft^2/ft	R = Area/Perimeter
S	0.102	ft/ft	Conservative estimate
Manning's n	0.024		Corrugated Metal Pipe
Q	11.2	cfs	Manning's Equation

Appendix G - Cost Breakdown

Pine Knoll Shores Drainage Study - Cost Estimation

Performed by:	DC	Date:	9/29/2022	Rev. 2	10/18/2022
Checked by:	CMD	Date:	10/3/2022		

AECOM

Street Reconstruction Costs

	Direction	Proposed Drainage	Width (ft)	Length (ft)	Cost[1,2] ($)
Thomas Rd	Two-way		24	660	$ 88,000
Miriam Rd	Two-way	Conduit	24	1,230	$ 164,000
Arnold Rd	One-way	Conduit	16	520	$ 46,000
Carter Rd	Two-way		24	1,500	$ 200,000
Shore Dr	Two-way	Conduit	24	970	$ 129,000
Shore Dr	One-way		16	330	$ 29,000
Mayhew Rd	One-way	Swale	16	1,100	$ 98,000
Rennie Rd	One-way	Conduit	16	670	$ 60,000
Longa Rd	One-way	Swale	16	1,600	$ 142,000
Richards Rd	One-way	Conduit	16	500	$ 44,000
Donald Rd	Two-way		24	450	$ 60,000
Subtotal					**$ 1,060,000**
General Inflation (10%)					$ 106,000
Contingency (25%) AND Design (10%)[3]					$ 408,100
Total					**$ 1,574,100**

[1]Based on Town of Merrimack standard unit price of $50/SY for Full Box Reconstruction. Some roads may have suitable material in place making $20/SY Reclaim and Pave cost more applicable.

[2]Excludes cost of proposed drainage.

[3]Contingency and design includes both the project subtotal and general inflation

Pine Knoll Shores Drainage Study - Cost Estimation

Performed by:	DC	Date:	9/29/2022	Rev. 2	10/18/2022	AECOM
Checked by:	CMD	Date:	10/3/2022			

Town Land BMP Construction

			12 Mayhew Road		5 Richard Road		17 Miriam Road	
	Unit	Cost[1]	Qty	Cost	Qty	Cost	Qty	Cost
Clearing	SY	$5	800	$ 4,000	400	$ 2,000	2,670	$ 13,350
Excavation	CY	$20	185	$ 3,700	170	$ 3,400	805	$ 16,100
Bioretention Filter Media[2]	CY	$70		-	95	$ 6,650	400	$ 28,000
Vegetation Establishment	SY	$12	550	$ 6,600	200	$ 2,400	1,000	$ 12,000
Crushed Gravel for Drives & Walkways	CY	$40	50	$ 2,000	20	$ 800	140	$ 5,600
Plantings	EA	$100	115	$ 11,500	45	$ 4,500	210	$ 21,000
Drainage Pipe	LF	$60	40	$ 2,400	90	$ 5,400	100	$ 6,000
Pipe End	EA	$1,000		$ -		$ -	2	$ 2,000
Drainage Structures	EA	$5,000	1	$ 5,000	2	$ 10,000	1	$ 5,000
Subtotal				**$ 35,200**		**$ 35,150**		**$ 109,050**
General Inflation (10%)				$ 3,520		$ 3,515		$ 10,905
Contingency (25%) AND Design (10%)[3]				$ 13,552		$ 13,533		$ 41,984
Total				**$ 52,272**		**$ 52,198**		**$ 161,939**

[1]Unit prices adapted from NHDOT Weighted Average Unit Prices 2021 and EPA Stormwater BMP Guidance Documents

[2]Assumes the average cost of "Granular Backfill: Sand" and "Sand" from NHDOT Unit Prices

[3]Contingency and design includes both the project subtotal and general inflation

Cost Estimation by Phase

				Phase 1 (Central)		Phase 2A (North)		Phase 2B (Southeast)		Phase 3 (Southwest)	
				Carter, Rennie (North)		Miriam, Shore (North), Arnold (North), Thomas		Mayhew, Longa (East), Rennie (South)		Shore (South), Longa (West), Richard, Donald	
		Unit	Cost[1]	Qty	Cost	Qty	Cost	Qty	Cost	Qty	Cost
Roadway Paving & Drainage Improvements	24' Roads	SY	50	4,000	$ 200,000	1,820	$ 91,000		$ -	3,790	$ 189,500
	16' Roads	SY	50	305	$ 15,250	3,700	$ 185,000	4,800	$ 240,000	1,780	$ 89,000
	Swale	ft	40		$ -		$ -	1,000	$ 40,000		$ -
	12" Pipe	ft	60	640	$ 38,400	845	$ 50,700	450	$ 27,000	230	$ 13,800
	18" Pipe	ft	80		$ -	225	$ 18,000		$ -		$ -
	24" Pipe	ft	155	810	$ 125,550		$ -	220	$ 34,100		$ -
	Stuctures[2]	ea	5,000	12	$ 60,000	13	$ 65,000	7	$ 35,000	3	$ 15,000
	Outfall	ea	10,000	1	$ 10,000		$ -		$ -		$ -
Tree Box Filters[3]		ea	30,000	5	$ 150,000		$ -	1	$ 30,000	1	$ 30,000
Hydrodynamic Separator[3]		ea	20,000	1	$ 20,000		$ -		$ -		$ -
17 Miriam Road Project		LS	1		$ -	109,050	$ 109,050		$ -		$ -
5 Richard Road Project		LS	1		$ -		$ -		$ -	35,150	$ 35,150
12 Mayhew Road Project		LS	1		$ -		$ -	35,200	$ 35,200		$ -
Mobilization		ea	5,000	1	$ 5,000	1	$ 5,000	1	$ 5,000	1	$ 5,000
Subtotal					**$ 624,200**		**$ 523,750**		**$ 441,300**		**$ 377,450**
General Inflation (10%)					$ 62,420		$ 52,375		$ 44,130		$ 37,745
Contingency (25%) AND Design (10%)[4]					$ 240,317		$ 201,644		$ 169,901		$ 145,318
Total					**$ 926,937**		**$ 777,769**		**$ 655,331**		**$ 560,513**

[1]Unit prices adapted from NHDOT Weighted Average Unit Prices 2021 and EPA Stormwater BMP Guidance Documents

[2]Structures include inline manholes at pipe junctions and at a 300-foot spacing for maintenance access combined with offline catch basins at a 200-foot spacing (assumed) along the drainage alignment

[3]Approximate pricing provided by Contech Engineered Systems, Inc.

[4]Contingency and design includes both the project subtotal and general inflation

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